Summer Meeting Issue

SAE journal

JULY 1956

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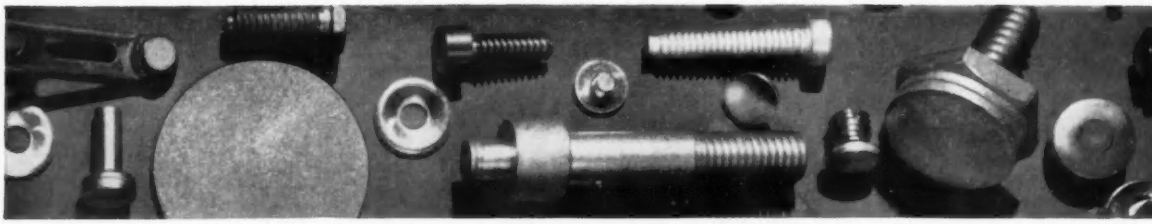

Flat Face vs Radius Face in Electrical Contact Design:

In theory, two clean, perfectly flat surfaces maintaining perfect alignment under equalized pressure, would comprise the ideal electrical contact.

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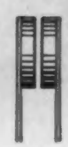
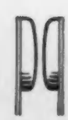


Two flat face contacts are best in theory, but often difficult in practice



Two radius face contacts are recommended for many applications; especially when ductile contact materials are used

A radius face contact paired with a flat face contact is often used when wiping or rubbing action is employed

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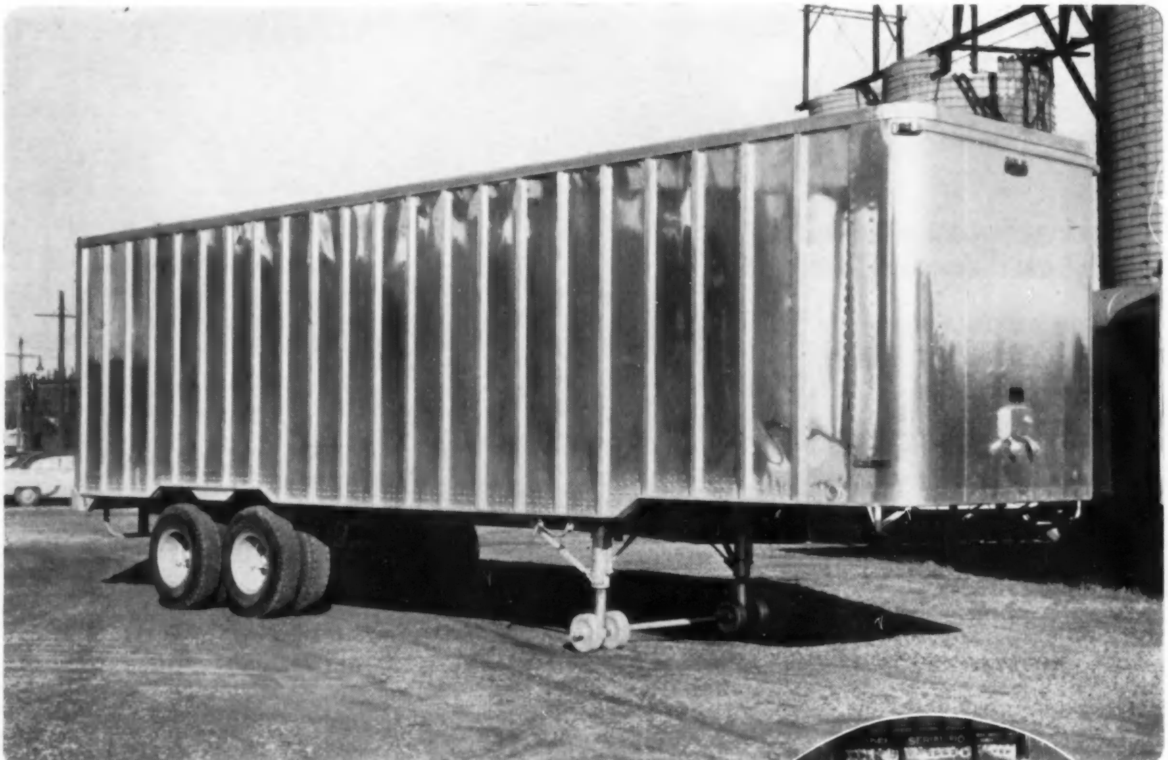

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For the Sake of Argument

Good Is Best When on the March . . .

By Norman G. Shidle

If attitudes change lives, as James Bender says they do, then emphasis is almost as important as direction in our thinking.

If all constructive projects seemed equally worthy, our lives might be lived just doing in order whatever came to hand. If all virtues appeared equally desirable, we might spend most of our time refraining from evil; little of it doing any good.

Tolerance, for example, can sometimes be over-emphasized as a virtue. It's so much easier to tolerate your fellow man than to love him . . . so much less demanding to refrain from criticism than to pitch in and help. Fairness can be futile if one merely thinks fairly and lets it go at that.

It's good to be willing to admit an error. But it's better to create an improvement while making the correction.

Happiness ripens more fully from doing good than from being good . . . even though both can be counted as virtuous. Noted psychologist William H. Sheldon tells us: "Happiness is essentially a state of going somewhere, wholeheartedly, one-directionally, without regret or reservation." Only in pursuit of a positive good do we get release from what Mildred Cram calls "the suffering of aimlessness."

The negative virtues sometimes reveal a chameleon-like quality. Exposed to over-emphasis, they tend to recolor with the hues on their opposites. Tolerance begins to look like intolerance . . . religion like ritualism . . . fairness like mercilessness.

Good bears its finest fruit when it emerges from our hearts to move in and through our lives.

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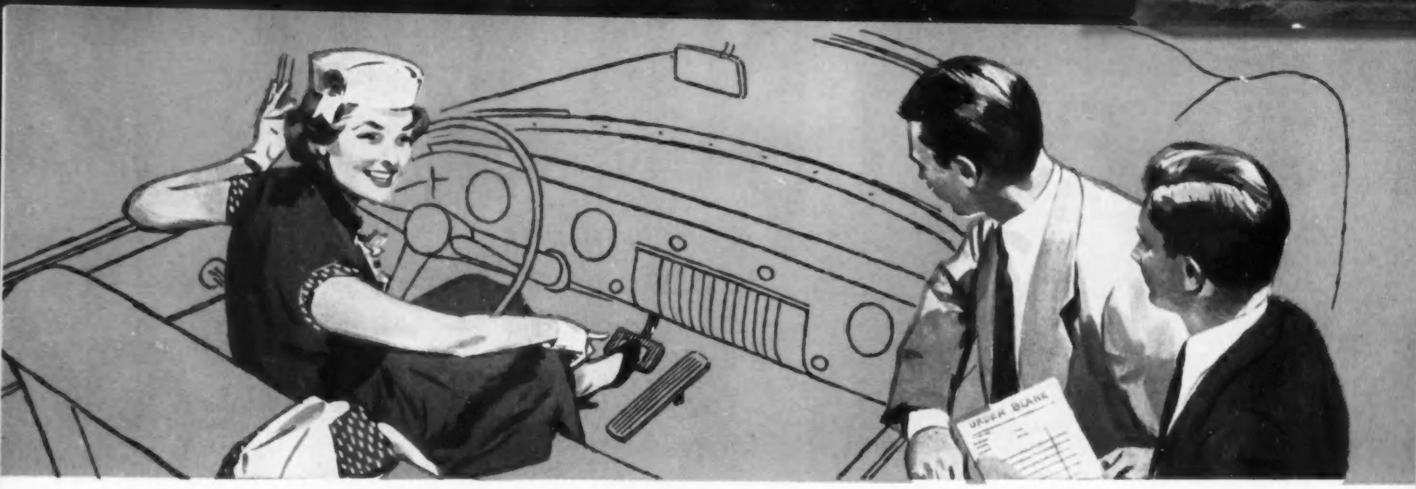
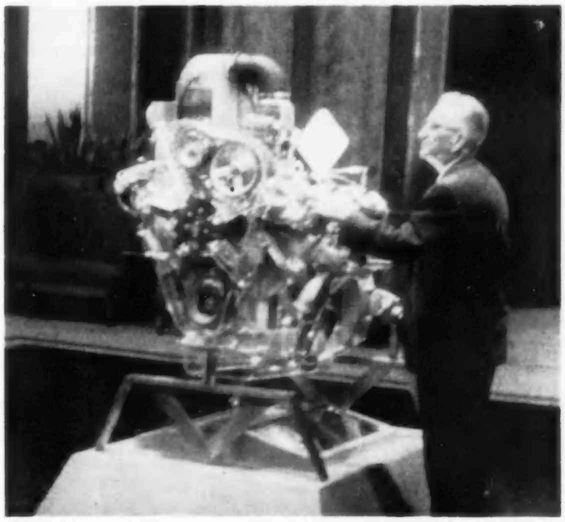


1956 SAE Summer Meeting

Attacks Power Loss from Fuel to Wheel



AMONG THE TECHNICAL DISPLAYS at the meeting this year was this new International Harvester V-8 piston engine. Foreign cars, new experimental models, free-piston and turbine engines were among other items available for inspection.

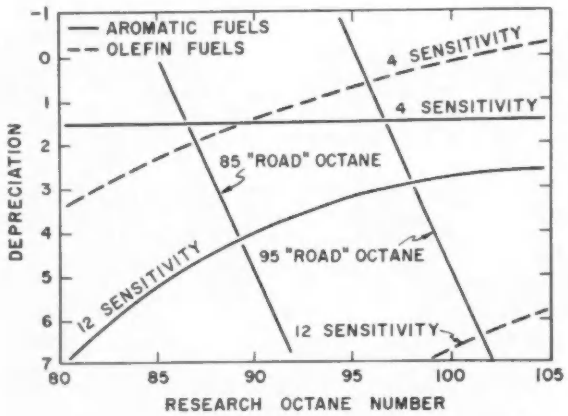
AT THE SAE SUMMER MEETING, engineers concerned themselves with devising better ways to convert the chemical energy of petroleum into the kinetic energy of a vehicle in motion. They talked about improved ways to use fuels, engines, transmissions, accessories, suspensions, tires—even the road itself—to put this energy in the hands of motor vehicle drivers with a minimum of waste and a maximum of comfort.

In committee meetings and in formal technical sessions, it was clear that automotive engineers are not content to have only a quarter or a third of the chemical energy of the average fuel converted to mechanical work by the engine. Also accessories such as fans, air cleaners, generators, and mufflers are being studied for ways to reduce the bite they take from engine power. Attack for improvement continues as well on the losses in transmission as the power is delivered to the wheels. Results of betterment are coming through, too, from continued investigations into air resistance, tire friction, and rolling resistances on the road.

All of the technical interchange at the Meeting was predicated on continued use of petroleum as the source of energy. Any hopes for early use of fission energy were dashed with the statement that deriving mechanical power via heat energy from nuclear fuel will be impractical until we can use heat energy at far higher temperatures than present materials permit.

Nuclear-powered ground vehicles will require major technological break-throughs not now in sight, it was said. Progress will depend on development of new types of reactor fuels, reactor containers, coolants, working fluids for heat engines, shielding materials, and heat-resistant materials. The feel-

PLANNING FOR PROGRESS took place in scores of administrative and technical committees, as well as in informal sessions during this June 3-8 Summer Meeting at Atlantic City. . . . The recently appointed Planning for Progress Committee, for example, agreed that "participation, continuity, and flexibility" are concepts to emphasize in exploring possible modification of the Society's structure to best meet future growth needs. In the photograph are PFP Chairman R. J. S. Pigott (center); Leonard Raymond (left); W. Paul Eddy (right). Also a member of the PFP Committee is B. B. Bachman. . . . More than 50 other SAE Committees met and made progress during the Summer Meeting.



FUEL quality and composition versus performance—2500 rpm.

ing was that workable answers to the sum of these needs are decades away.

Meantime, engineers are making it possible to turn more of the chemical energy of petroleum fuels into mechanical power—both through better fuels and improved engines.

Engine-Fuel Octane Relationships

To provide passenger-car owners with maximum power and economy, a balance must be maintained between gasoline antiknock quality and car octane requirements. Despite untold amounts of money spent by both automotive and petroleum industries to keep this balance, the power of modern high-output engines is still being limited by fuel antiknock quality.

One important phase of this problem is the determination of octane ratings of fuels. Road octane ratings are needed, but are expensive and time-consuming to determine. Hence, there is great interest in finding a rapid and accurate laboratory method of road octane determination.

Four different approaches to the problem were presented at the meeting:

1. Predicting the road ratings by means of an equation based on the Research and Motor ratings of the fuel.
2. Determining the road rating from Research octane number, fuel sensitivity, and hydrocarbon composition.
3. Improving knock test methods by modifying the shape of the combustion chamber of the single-cylinder laboratory engine.
4. Predicting the road ratings with a single-cylinder lab engine that duplicates the combustion environment of the full-scale engine. This means varying lab-engine operating conditions to give the same end gas temperature, density, and time of burning as in the full-scale engine.

The first method of predicting road ratings utilizes an equation based on Research and Motor octane numbers, as follows:

Road ON $= m_1$ (Research ON) $+ m_2$ (Motor ON) $+ C$

The coefficients m_1 and m_2 are constant in any given car at any given speed at which knock occurs. They are equal to the change in road ON per unit increase in Research and Motor ON's, respectively. The integration constant C is a correction factor that must be added to or subtracted from m_1RON + m_2MON to give the correct numerical value of road octane number.

The author reporting on this equation said that his data indicated there were no significant hydrocarbon-type effects in the fuels studied, in cars of 6.5/1 to 9/1 compression ratio. Other authors and discussers disagreed with this, reporting that hydrocarbon type has very definite effects that must be considered when trying to predict road ratings. For example, one author reported that ratings of aromatic blends decreased with increase in engine speed much less than did olefinic blends.

Some investigators are going even farther than this. One of them pointed out that the fuel composition must be known in more detail than just that it is paraffinic, olefinic, or aromatic. Since this is not always easy to do for commercial products, he suggested that it may be more expedient actually to determine the road octane number of the fuel in the first place!

Left is a graph developed to show how the antiknock requirements of high-compression engines can be developed in terms of Research octane numbers, sensitivity, and hydrocarbon composition, for a certain engine at 2500 rpm. Superimposed are lines of constant "road" octane number assigned by the engine. An engine requiring 95-octane primary reference fuel would be satisfied by an olefinic fuel of 4 sensitivity and 95.5 Research octane number. At 12 sensitivity, a fuel of 101.5 Research octane number would be required. This engine would also be satisfied by aromatic fuels of 96.5 Research with 4 sensitivity or 98 Research with 12 sensitivity. Thus, at the 12 sensitivity level, the road-octane advantage of an aromatic fuel would be the difference between 101.5 and 98, or 3.5 units over an olefinic fuel, and all of these fuels would give the same power output as limited by antiknock quality.

Since present ASTM knock test methods do not accurately predict road octane ratings, it was suggested that cylinder and combustion-chamber design should be modified to give better results. One author presented results with a chamber modified as shown on page 19. An important feature of this domed construction is that the more nearly central location of the spark plug gives a reasonably short burning path and the coning creates a mild squish turbulence. It was felt not to be practical to include an automotive-type quench zone and still provide for continuously variable compression ratio adjustment. The importance of this work was emphasized by one discusser, who reported that a section of the ASTM Research Division I of Committee D-2, which has the responsibility of improving knock test methods, is giving serious consideration to such changes.

The fourth method of predicting road ratings, by development and application of basic concepts of combustion involving time, temperature, and density was generally considered technically sound. Unfortunately, it appears that we do not yet have the instruments to measure exactly these conditions in the combustion chamber when knocking occurs. It was reported that all of the experimental work car-

ried out so far has been on a trial-and-error basis, along with mathematical calculations for compression density and temperature. Obviously, these calculations are not true end gas densities or temperatures; hence, the degree of error entering this approach is not truly known. Nevertheless, the limited data that have been obtained appear to support the concept.

New V-8 Gasoline Engines for Trucks

The work on gasolines has not been done in vain, despite the advent of turbine engines, it was obvious.

Ten years ago, participants in SAE meetings were foreseeing the eclipse of the piston engine by the turbine engine for all vehicles. Yet this Meeting brought a description of a family of new V-8 gasoline engines for truck use. The engines are the International Harvester V-401, V-461, and V-549 engines, rated at 206, 226, and 257 hp, respectively.

Compression ratio is 7½ to 1 for the smallest engine and 7 to 1 for the larger two. But the engines have already been run at around 10 to 1 in the laboratory. And those who heard them described seemed to feel there was no reason why the engines couldn't be modified to give good service at such a ratio when suitable fuels are available.

When it was pointed out that horsepower depends not on compression ratio alone but on pressure—or the product of compression ratio and volumetric efficiency—the engines' designers revealed that volumetric efficiency of the installed engine is 83–85%.

While the engines won't quite fit in the glove compartment, as engine men claim stylists desire, the engines are only about 40 in. long and still they will go within the usual 34 in. frame.

Only criticism of the engine was that the scavenging system can feed blowby gases back into the combustion chamber. Separators take out the oil but, it was pointed out, the unburned fuel and oxides of nitrogen that aren't removed can gum the chamber. The oil industry can't be responsible for the fuel the second time it goes around, said one of its engineers.

Turbines Take Two Routes to Economy

While the piston engine is apparently going to be the bread-and-butter engine for some years to come, the gas turbine's possibilities are being pursued vigorously, the Meeting showed. In order to achieve good fuel economy without using extreme-temperature materials in the turbine, General Motors is developing both the regenerative type and the free-piston type.

The GM Whirlfire (described in detail on pages 48, 52, 53, 54, 55 of this issue) has a rotating regenerator drum that picks up air leaving the compressor and before delivering it to the burners, whirls through a plenum chamber containing the hot gases exhausted from the turbine. In this way, heat energy that would otherwise be wasted is added to the working fluid . . . less fuel has to be burned to raise the fluid to turbine inlet temperature . . . and the engine's exhaust is cooled.

The GM Hyprex powerplant (described in detail on pages 60–66 of the June issue of SAE Journal) takes the free-piston gasifier route to low fuel consumption and avoidance of need for scarce high-temperature-resistant materials. Each of its two

gasifier cylinders contains a pair of opposed double-ended pistons. The pistons operate on a two-stroke compression-ignition cycle. But unlike conventional diesel engines, the pistons are forced together on their compression stroke by energy stored in air compressed by the outer faces of the double-ended pistons.

The gasifier cycle has good efficiency, so fuel consumption is reasonably low. Also, since the energy for compression has been taken out of the working fluid before it leaves the gasifier to enter the turbine, the gases don't have to contain so much heat energy. The gases are relatively cool, around 900 F.

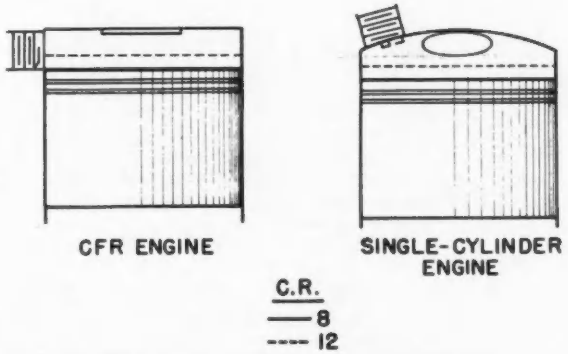
Ford, too, is experimenting with the free-piston type of turbine powerplant, it was disclosed—probably for the first time publicly—at the meeting. Discussion brought out that Ford has been working with free-piston gasifiers for use with turbines since February 1954. Several units have been built and tested to study thermodynamic and mechanical problems.

Slides shown indicated that Ford is using a rack-and-pinion arrangement to synchronize the gasifier's opposed pistons. The GM Hyprex uses a linkage device.

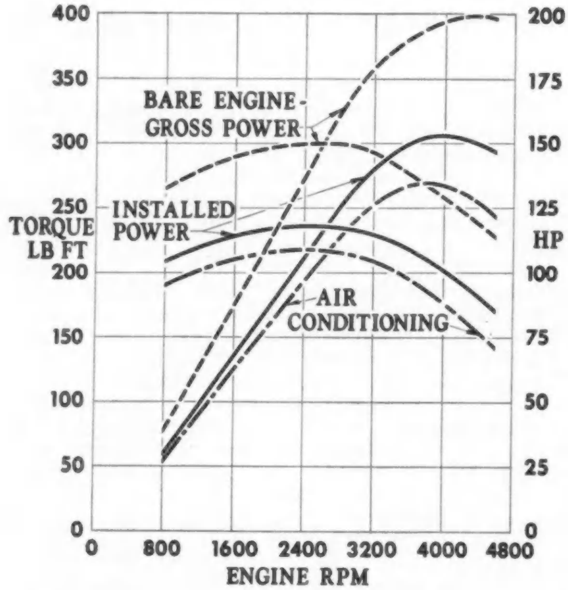
Reducing the Big Bite — Accessories

Some of the power delivered by the crankshaft never gets to the vehicle wheels. At 50 mph about 25% of the gross engine horsepower goes out the front end of the crankshaft to run accessories such as the fan, generator, power steering pump, and windshield wipers. An air conditioner takes up another 7%. So the peak horsepower available at the flywheel of an engine rated at 200 hp is often no more than 145 hp.

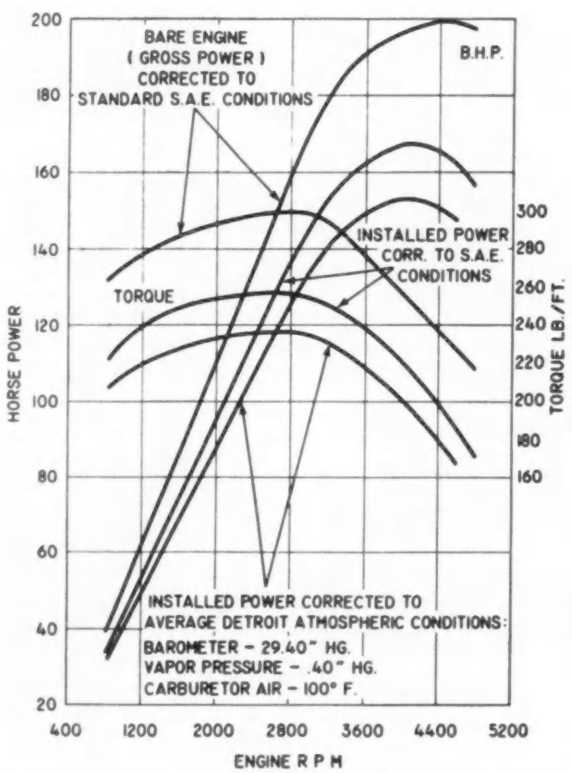
One of the several factors affecting the fan power requirements is radiator efficiency. At the Summer Meeting, SAE members were told that efficient radiators made all or partly of aluminum were a commercial possibility in the near future. Aluminum is light and has good heat transfer characteristics which make it desirable for use in automotive radiators. Scarcity and high cost of copper—which has



COMPARATIVE combustion-chamber geometry.



ENGINE accessories, such as fan, generator, power steering pump, and air conditioner use from 25 to 35% of the gross engine power.



ABOUT 16% power is lost in components such as muffler, air cleaner, automatic distributor, and manifold heater on an installed engine.

been used for radiators—have stimulated new interest in aluminum.

Until recently aluminum radiators have not been feasible because of difficulties in mass-manufacturing them at low cost, susceptibility to corrosion, and difficulties in repairing leaks. However, radiators of soldered aluminum fins and brass tubes can now be made to perform satisfactorily, it was reported. Some engineers said that it will be only a short time until manufacturing techniques are devised that will make aluminum radiators as economical to produce as copper radiators.

One company, after extensive research with many joining materials, is using a solder comprised essentially of about 30% tin and 70% zinc. Special flux—an aqueous solution of hydrazine compounds and their organic derivatives—performs well and leaves very little corroding residue. Head sheets are now being soldered to the tube ends by dipping, but whether too much zinc will build up in the tin-lead pots remains to be seen. Radiator tube leaks are still difficult to repair and this problem is magnified by the protective chromate coatings which are necessary.

Another company reported that of 29 brazed, all-aluminum radiators installed in test automobiles, only three are still in service after 58 months and 76,000 miles. Others suffered from poor welds, leaks, or accident damage. Leaks came from pit corrosion on the outside of the tubes, so a new group of radiators is being tested with a protective treatment of Alodine #100 and a coat of paint.

Another accessory — the air conditioner — may make car occupants comfortable, it was brought out, but it pours heat under the hood, interferes with radiation, affects engine operation by causing vapor lock, and otherwise drains power from the engine.

The meeting was told that the refrigeration compressor, which is usually driven by belt from the crankshaft front pulley, takes considerable power from the engine. The faster the engine turns, the greater the drain.

A second radiator, which is usually placed in front of the engine radiator, is needed to condense the compressed refrigerant. A larger fan is needed to pull additional air through the two radiators and more power is intercepted before it can get to the driveline.

As to how much effect the air conditioner and its heat has on the vapor-locking tendencies of a car, there seems to be some difference of opinion.

One speaker reported that:

1. Tests of 12 air conditioned cars showed car Reid vapor pressure limits were reduced 0.7 psi, on the average, when the units were operated.

2. Tests on three cars before installing one type of unit showed that car Rvp limits were reduced 1.3 psi, on the average, when the units were installed but not operated and were reduced an additional 0.6 psi when the units were operated.

On the other hand, a discusser said that his studies of proving ground test results led him to the following rather different conclusions:

1. Operating conditions have so much effect on the relative vapor-locking tendencies of cars that

air conditioners can be shown to have no effect or a harmful effect on vapor lock, depending on how the tests are conducted.

2. Because of continued testing and development, the older cars are more likely to suffer from increases in fuel volatility than newer cars—in spite of changes in engines, styling, and accessories.

However, it seemed pretty clear that, although there may be some question as to the seriousness of the problem today, it will certainly get serious, if there is any relaxation in efforts to minimize air conditioning effects on car Rvp. One reason for this is that the design that seems most likely to be generally adopted is the front-mounted system. This entire system is mounted in the front of the car, which means that a lot of extra heat is released in the engine compartment.

Meanwhile other ways of keeping car Rvp limits down are being studied. One of these discussed at the meeting is the improvement of the fuel pump—another accessory that requires some of the engine power. There has been some talk of replacing the present diaphragm-type pump with the pusher type in the fuel tank. Many seem to feel, though, that it is somewhat premature to discard the diaphragm type, which has given reliable service for years, is cheap, and durable. Its proponents feel that it should not be discarded until we are sure that its full potential has been realized.

Methods of obtaining improved vapor handling already in use for the diaphragm pump were reported to be:

1. Use of larger displacement pumps, with less internal restriction, which would handle a given quantity of vapor satisfactorily.

2. Relocating the pumps on the engines and the lines and accessories so that there is less tendency for vapor to form.

One speaker suggested that further improvement might be obtained by running the fuel pump at engine speed rather than cam speed.

One possible fallacy pointed out was that in improving vapor-handling capacity with the higher pump speed, the vapor-forming tendency of the system might be increased. This might partially offset the increase in vapor-handling capacity. It appears that road tests are needed to determine the answer. The customary acceleration-type vapor-lock tests on the road add the complicating effects of transients and float bowl capacity. These are absent from the steady-state bench and chassis tests.

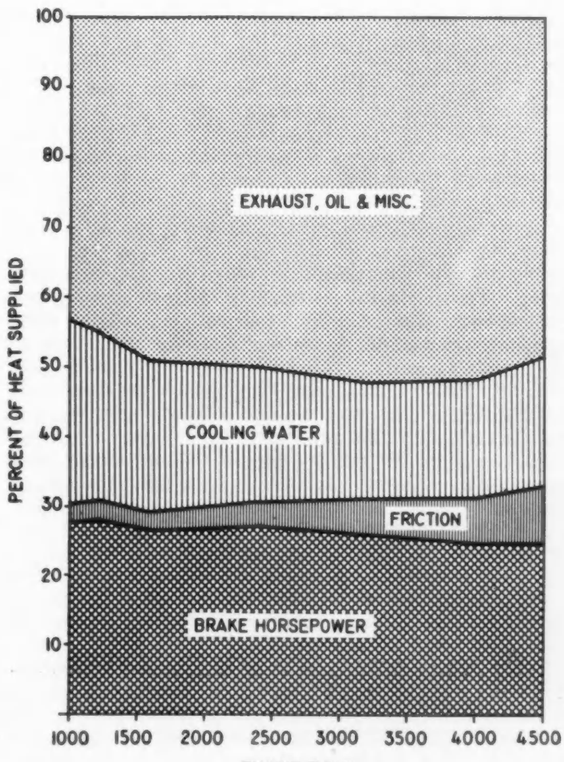
One other item reported to need considering is that the carburetor may not be able to handle a V/L of, for example, 64, even though the weight flow should be sufficient to supply the engine demand. Thus, the relationship between vapor-forming tendency and vapor-handling capacity must be fully understood and the results applied to the improvement of pump designs before the full potential of the diaphragm-type pump may be achieved.

The Power Cost of Automatic Transmission

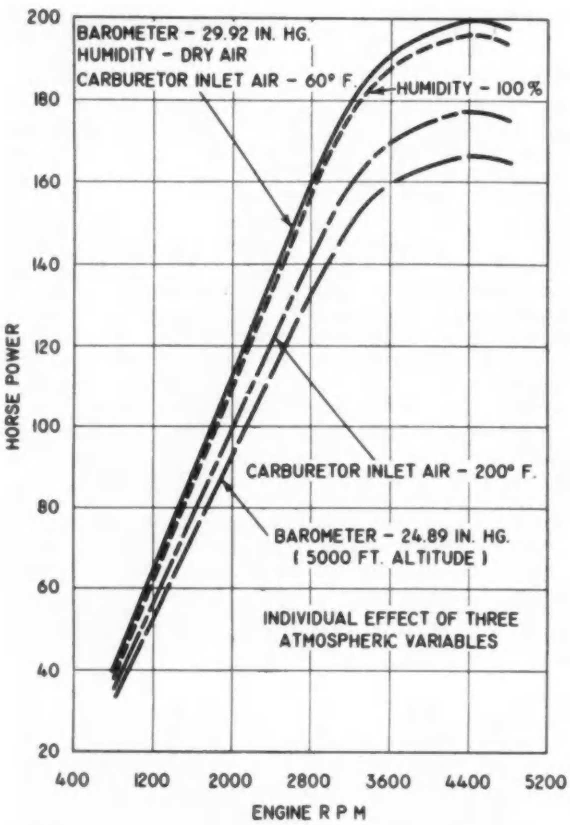
Automotive engineers are constantly trying to make engine components and accessories more efficient so that less power is lost on the way to the wheels. Yet, paradoxically, most engineers are willing to lose even more power by installing an automatic transmission. By "spending" about 11% of the available horsepower, they get more use out of the power that is left.

The automatic transmission selects the proper gear ratio to give the best performance and fuel economy at normal car speeds. However, the friction bands, clutches, and hydraulic pumps use power in shifting the planetary gears. About 3 hp escapes in the form of gearbox friction heat. The transmission fluid pumps absorb about 4 hp. And the hydrokinetic torque converter, or fluid coupling, wastes some power due to slippage.

A manual transmission, it was said, is more efficient and therefore can transmit more horsepower to the shaft than an automatic transmission. But, the automatic transmission permits the engine to *develop* more power at low and moderate speeds. So even with lower transmission efficiency, more useable power is *delivered* to the wheels. Also, the lower efficiency is significant only during high speeds, which are a small percentage of total car operation. Too, the slightly lower efficiency is bal-



DESPITE the tremendous potential energy of gasoline—about 114,000 Btu per gal—most of it is wasted as the chemical energy is converted first into heat energy and gas pressures, next into mechanical rotation, and finally into forces to push the car. At wide open throttle only about one quarter of the available heat energy of the burned gasoline is used.



NORMAL day-to-day variations in humidity and barometric pressure can vary engine output about 10%.

anced by the practicability of using a lower axle ratio. Thus, an investment of a few horsepower expended in the automatic transmission yields dividends in terms of smoother, quieter performance at most car speeds.

The advantages of an automatic transmission have taken such a hold on the public and the automobile industry that, as one engineer observed, some transmissions are getting larger and more complex than some engines. It was agreed that transmissions are getting an inordinate amount of engineering development attention. Engine designers are crying, "If I could have another hundred bucks for engine improvements, a complex transmission wouldn't be necessary." The transmission designers are retorting, "Give me another hundred bucks and you won't need an engine."

Early in the development of automatic transmissions, it was discovered that their satisfactory operation would depend, in good part, on the availability of high quality lubricants specifically designed for this use. This led to the development of automatic transmission fluid, type A, which is now recommended by every passenger-car manufacturer in this country.

The specification on which this fluid is based has been successful in that the various makes of fluid meeting it have given generally good performance. It appears, nonetheless, that certain features of the specification require modification, the Meeting revealed. Among these are:

1. The Chevrolet L-4 test is not considered to be completely satisfactory as a test for oxidation stability.
2. Viscosity requirements need reevaluation. For example, the low-temperature requirements are considered by some to be too severe.
3. Many parts of the spec are too vague.

The suggestion made by the authors of one of the papers that the Powerglide test be substituted for the L-4 test was not met with unqualified enthusiasm.

It does have the advantage that the fluids are tested in an environment similar to that of actual service. This is an improvement on the L-4 test, where the fluids are tested in an engine, and thus are subjected to combustion products not encountered in transmission operation.

Powerglide Test Versus L-4

It has also the advantage that it can be conducted over a longer period of time, with more or less stringent conditions. The L-4 test measures stability for a 36-hr period only. One discusser pointed out that a 300–500-hr period of torque converter operation at temperatures actually encountered in service would be a considerable advantage in the search for better fluid and additive combinations.

Opposition to the Powerglide test centered around the authors' data, which showed that three out of 12 already qualified type A fluids failed in this test, due to heavy sludge formation, and two others failed due to light or moderate sludge formation.

It was emphasized that such difficulties must be ironed out before any change is made. The important point is that the test must not be unduly severe, and must correlate well with actual service experience.

Similar problems have arisen in regard to the viscosity requirements. The coldroom test at -10 F is considered more severe than is actually encountered in service.

It was pointed out that creating such unduly severe requirements can defeat the objective of obtaining improved products. In meeting one overly severe requirement, some compromises must usually be made in other desirable properties, and the consumer may have to pay more for some unnecessary characteristic.

Present Test Called Vague

Another discusser pointed out that the vagueness of the spec presents serious problems to those desirous of marketing approved type A fluid. He said that out of 21 requirements in the 1951 specification, definite limits are given for only five. For the other 16 requirements the only limits are described by the word "pass." He reported that this adds greatly to the confusion and administrative problems associated with the type A qualification program.

He suggested a new specification be set up, desig-

nated type AA, in which requirements known to be essential and reasonable be clearly defined. Into this spec, he said, transmission engineers and petroleum technologists could incorporate the requirements met by the better of the already available type A products. Such a spec would, he felt, leave the present system undisturbed and, at the same time, would promote progress by establishing a target for the petroleum industry in the development of improved products.

Overcoming Power Losses on the Highway

Engineers at the meeting were intrigued with the many problems associated with regaining the power that is lost due to air and rolling resistances of an automobile. Torquemeters indicate that seal friction, churning losses, and bearing losses reduce axle efficiency about 5%. For a typical car at high speeds nearly 4 hp are required to increase car speed 1 mph.

About 2 hp or 14 lb-ft of torque can be saved by selecting tires of a combination synthetic and rubber composition that have lower rolling resistances. Higher inflation pressures will reduce tire deflection and flexing, and consequently reduce rolling resistance.

Air temperature has a very marked effect on road load torque and power dissipation. For instance, at 60 mph it takes about 5½ hp more to propel a car at 30 F than at 70 F.

Wind and air resistances are also factors in absorbing horsepower. The low slung and aerodynamically styled Firebird II and Free Piston XP-500, exhibited at the meeting, were evidence of what engineers are doing to save this power.

Power and the Driver

The automotive engineer has been primarily concerned with taking the most power possible from the fuel with the least waste and giving it to the driver in the form of torque at the vehicle wheels. He also recognizes that he must provide the driver with means to control it. That means the driver must have a steering mechanism to direct power quickly and firmly and a suspension system that will permit the driver to make use of the power with comfort.

The meeting was told that the science of vehicle "handling" undoubtedly lags behind the stability of control theories developed for aircraft and ships. Particularly at high speeds some automobiles have a tendency to yaw, oversteer, and understeer, depending upon their design and the road design. The higher the speeds the more difficult it is for the driver to control his vehicle and compensate for dynamic instability due to poor design.

Before the dynamics of vehicle control can be solved there is need for basic data on tire mechanics, vehicle aerodynamics, steering mathematics, and road design. Also, we must determine scientifically just what handling qualities a driver wants and needs.

The Meeting was told that it may be possible to design highways with curves, hills, valleys, and bumps so gentle as to give the effect of an infinitely long and utterly smooth, straight road. (This has been done to a limited extent in developing a test track which permits high speed driving without steering drag, undue tire wear, perceptible centrifugal motions, or forces different than experienced on a straight, level road.)

Highway geometry problems were characterized as an extension of the ride problem: Dips and turns are just big bumps in the road. Travelling across mountains and valleys is just a vibration of large amplitude and low frequency. If car suspensions can't smooth such bumps, maybe the bumps themselves can be shaped to give the ride motions we prefer.

Theoretically it is possible to design a road that will steer vehicles and keep them in the proper speed lane on curves. The driver would have to exert constant effort to drive out of the lane he is in. The road would have to be built for one-way traffic and with nothing but right hand turns.

Brakes Get Help from Retarders

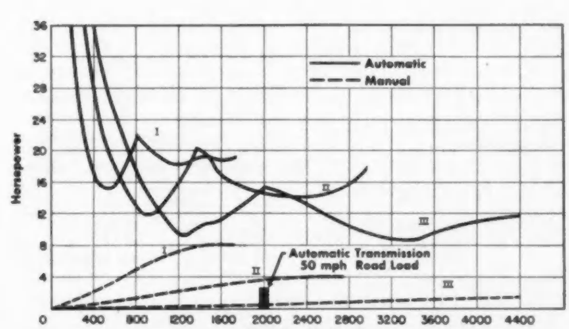
Of course, not all the energy available at the wheels is wanted at all times. That's why vehicles have brakes.

But wheel brakes are hard put to keep up with increased engine powers and vehicle loadings. There's a limit to the rate at which friction brakes can dissipate energy in the form of heat. So various devices have been developed to supplement the usual service brakes on long grades and in other situations requiring slow-downs. Four of these retarders were described at the Meeting.

Two of them, the Thompson retarder and the Parkersburg Hydrotarder, turn mechanical energy into heat via hydraulic fluid in a sort of stalled fluid coupling. The rotor rotates with the drive line or the axle. The retarder unit fills with fluid when the driver calls for retardation, empties when he rejects it.

A third retarder, the Warner eddy current retarder turns mechanical energy into heat via electrical means. Lifting the foot from the accelerator actuates the retarder. Depressing the accelerator pedal slightly releases it again.

The fourth type of retarder discussed was the



AUTOMATIC transmissions use between 10 and 18 hp at maximum speeds. At low speeds the losses can be even greater proportionately. However, the automatic transmission pays off in better car performance at normal operating speeds.

compression retarder. It converts mechanical energy into heat by letting the pistons pump up air into a closed-off exhaust manifold.

None of these devices, it was emphasized, can stop or hold a vehicle. Therefore they merely supplement—not replace—mechanical friction brakes.

The whole problem of emergency braking systems for truck-trailer combinations equipped with air brakes was thoroughly aired at the Meeting.

In reviewing the problem, speakers recalled that disastrous accidents with runaway vehicles focused attention several years ago on the fact that a leak in a tractor air system or in a trailer air system can bleed down the whole system, leaving the combination without any braking ability. Most experts on brakes agreed all along that a failure at one point should not be allowed to deplete the air pressure of the whole system. But they have disagreed on

Presentations at the Summer Meeting in Atlantic City, N. J. June 3-8, 1956

E. M. Barber
H. I. Wilson and T. H. Randall
The Texas Co.
"An Approach to Obtaining Road Octane Ratings in a Single-Cylinder Engine"

G. R. Beardsley and A. A. Catlin
International Harvester Co.
"International Harvester's Approach to the V-8 Engine Program"

J. B. Bidwell and R. E. Owen
Research Staff, GMC
"The Experimental Chassis for the Firebird II"

Godfrey Burrows
Chevrolet Motor Division, GMC
"New Techniques of Automobile Frame Manufacture"

E. S. Corner
Esso Research and Engineering Co.
"Octanes—From Laboratory to Road"

T. F. Davidson and J. H. Way, 1st Lt., USAF
Wright Air Development Center
"Correlation Between Laboratory and Engine Performance of Synthetic Turbine Lubricants"

C. J. Domke
N. D. Esau
D. S. Gray and H. R. Taliaferro
Standard Oil Co. (Indiana)
"Fuel Anti-Knock Performance in High Compression Engines"

Hyman Feldman
Transit Authority, City of New York
"Field Testing of Parts and Supplies—Urban Transit"

N. A. Hunstad
T. W. Selby and R. E. Osborne
Research Staff, GMC
"The Present Status of Automatic Transmission Fluid, Type A"

W. A. McConnell
Ford Motor Co.
"Motion Sensitivity as a Guide to Road Design"

F. L. Schwartz and H. A. Ohlgren
University of Michigan
"Automotive Nuclear Heat Engines and Associated High-Temperature Materials"

Leonard Segel
Cornell Aeronautical Laboratory, Inc.
"Research in the Fundamentals of Automobile Control and Stability"

J. P. Stapp, Lt.-Col. USAF
Aero Medical Field Lab., Holloman Air Development Center
"Human Factors of Crash Protection in Automobiles"

H. A. Tuttle and G. E. Noakes
Ford Motor Co.
"Applications of Radioactivity for Control and Testing of Automotive Materials"

W. A. Turunen and J. S. Collman
Research Staff, GMC
"The Regenerative Whirlfire Engine for the Firebird II"

A. F. Underwood
Research Staff, GMC
"A Concept of the Free Piston Engine for Automotive Use"

Volatility Symposium

M. R. Morrow
Humble Oil and Refining Co.
"Automotive Air Conditioners and Gasoline Volatility Requirements"

R. A. Randall
Research Staff, GMC
"Automotive Fuel Pumps—A Fundamental Study of Their Performance"

Symposium—Cavitation and Corrosion in Engine Cooling Jackets

A. K. Blackwood
International Harvester Co.
"Coolant Side Corrosion of Diesel Cylinder Sleeves—Means For Reducing"

J. A. Joyner
Government and Industrial Products Division, Studebaker-Packard Corp.
"Reduction of Cavitation Attack of Cylinder Liners"

W. Margulis and J. A. McGowan
ALCO Products, Inc. and
W. C. Leith
Dominion Engineering Co., Ltd.
"Cavitation Control Through Diesel Engine Water Treatment"

A. R. Schrader
U.S. Naval Engineering Experiment Station
"Investigation of Cavitation Erosion at U.S. Naval Engineering Experiment Station"

Bernard Trock
Ordnance Tank Automotive Command
"A Study of Cavitation Erosion"

Symposium — Latest Developments on Vehicle Retarders

J. H. Booth and E. J. Herbenar
Thompson Products, Inc.
"Thompson Retarder"

W. E. Meyer
Pennsylvania State University
"Compression Retarder"

J. G. Oetzel
Warner Electric Brake and Clutch Co.
"Eddy Current Retarder"

E. F. Speiden
Parkersburgh Rig and Reel Co., Division of Parkersburgh-Aetna Corp.
"Hydrotarder"

Symposium—Status of Aluminum Radiators

J. D. Dowd
D. G. Vandenburgh and E. P. White
Aluminum Co. of America
"Aluminum for Tomorrow's Radiators"

W. O. Emmons
Harrison Radiator Division, GMC
"All-Aluminum Brazed Heat Transfer Equipment"

W. S. Gale
McCord Corp.
"Aluminum Fin, Brass Tube Soldered Construction"

Symposium — Emergency Braking Systems for Combinations of Commercial Motor Vehicles

W. L. Bennett
Baltimore Transfer Co.
"Conversion of Present Equipment to the System of 'Individual Vehicle Protection'"

Stephen Johnson, Jr.
Bendix-Westinghouse Automotive Air Brake Co.
"Individual Axle Protection System Test Results"

B. G. Milster
Bureau of Motor Carriers, Interstate Commerce Commission
"Status and Interpretation of ICC Regulation"

H. T. Seale
H. T. Seale Co.
"Individual Item Protection"

John Thomas
International Harvester Co.
"Individual Axle Protection Against Run-aways"

Symposium — Where Does All the Power Go?

C. E. Burke and L. H. Nagler
American Motors Corp.
"The Engine — The Power Source"

E. C. Campbell
Engineering Staff, GMC
"The Accessories—The First Bite"

T. D. Kosier and
W. A. McConnell
Ford Motor Co.
"What the Customer Gets"

L. C. Lundstrom
General Motors Proving Ground
"Wind and Rolling Resistances"

W. E. Zierer and H. L. Welch
Chrysler Corp.
"Effective Power Transmission"

Round Table—Industry Report on Automotive Safety Research

Leader: A. L. Haynes
Ford Motor Co.

Round Table — Operator's Experience with Truck Tubeless Tires

Leader: W. A. Taussig
Burlington Truck Lines, Inc.
Secretary: Henry Jennings
Fleet Owner

Round Table — Developments in Seating

Moderator: E. C. Pickard
Ford Motor Co.
Secretary: F. C. Matthaei, Jr.
American Metal Products Co.

Round Table—The Place of the Plastics Industry in Automobile Body Design and Construction

Moderator: L. K. Merrill
Bakelite Co., Division of Union Carbide and Carbon Co.

Round Table—Range and Splitter Ratios in Transmissions and Axles

Leader: L. T. Flynn
GMC Truck and Coach Division, GMC
Secretary: R. W. Wolfe
New Process Gear Corp.

whether the combination should be protected vehicle by vehicle or axle by axle. And the matter wasn't settled in Atlantic City.

However, the symposium on the subject did make these points:

- The Interstate Commerce Commission issued a regulation on May 21, 1956 along the vehicle-protection concept. (The ICC had earlier proposed a regulation following the axle-protection concept, but dropped it because of vigorous protests—largely that the proposed rule would increase chance of brake-system malfunction through increased system complexity.) The order applies to truck-tractors and trailers manufactured after Aug. 31, 1956 and to all such vehicles operated under ICC jurisdiction after Jan. 1, 1957.
- The ICC may still decree axle-by-axle protection at a later date.
- Industry tests have proved it is possible to provide a vehicle combination with axle-by-axle protection without increasing normal air application times over that of the present conventional system. Braking stopping distances were the same.
- No brake system or multiplicity of brake systems will insure 100% safe operation of a poorly maintained vehicle. Well maintained vehicles meeting the ICC regulations on brakes as revised in 1952 have an excellent safety record.
- The simpler the entire braking system is, the easier it is to maintain. Unduly intricate controls may defeat their purpose.

Even with the best in brakes and other equipment accidents will occur, the Meeting recognized in dealing with crash protection in passenger cars.

Three things to guard occupants against are (1) ejection from the vehicle; (2) striking the steering wheel, windshield, instruments, door handles, or other similar objects; and (3) whiplash of the head and neck. The automobile industry's program of better door latches, delethalization of interiors, and provision for lap belts is combatting the first two hazards. The third is not yet licked.

Statistics were quoted to show that being thrown clear of the vehicle in a crash about doubles risk of serious injury. The safety door latches adopted generally throughout the industry within the last year or so do prevent ejection. Their advantage lies in greater overlap between striker and rotor.

In broadside collisions, which stretch the side opposite the struck side, the elasticity and overlap in the new latches keeps the doors closed. The same is true in head-on collisions—where the forward door is forced back against the pillar, the pillar deforms, and the door tends to spring back to shape before the pillar does.

Lap belts help, too, in preventing ejection, especially in pre-1956 cars which do not have the improved door latches.

Besides, a lap belt can keep a driver in position where he can maintain control of his car after impact. In minor accidents, there's always the danger that the car will go out of control and suffer a second, more serious mishap. The lap belt may prevent the second accident by minimizing the first.

Even where a vehicle plunges into water or catches fire, lap belts may be more of an advantage

than a disadvantage, it was pointed out in response to these classic objections. A lap belt may be the means of keeping an occupant from injury that would render him unconscious and unable to exit—and the belt adds only about 1 sec to the time he needs to get out of the car.

These advantages stem only from belts that don't narrow to a width too small to distribute the forces properly over body tissue — and that are strong enough in webbing, buckles, and attachments to stand the loads imposed. To test strength dynamically, the University of California—which tests belts for the state's approving agency, the California Highway Patrol—uses a drop test rig. The belt ends are fastened about 16 in. apart to the top of the test frame. In the U formed by the belt is suspended a weighted body mold. The frame is raised to a selected height, then dropped onto a hydraulic stop. (The height to which the frame is raised is selected according to the desired simulated crash speed. The hydraulic valves are proportioned to give the desired deceleration pattern.) The stop decelerates the frame just as a bridge abutment would decelerate a car. But the body mold continues downward, as a passenger would be thrown forward.

Passenger car manufacturers are using another new method for testing seat belts and studying results of crashes. In movies, they showed how a tow car pulls the test car along until it is yanked backwards by a snubbing device attached to the rear of the frame of the test car and fastened by a long cable to a securely imbedded post. (The link between tow car and test car is released simultaneously with the start of snubbing action.)

Anthropometric dummies within the test car undergo decelerations very similar to those imposed in barrier tests. Yet test cars are not smashed in the process.

Cavitation

Stray energy received part of the blame for another form of destruction: cavitation-type attack in engine cooling jackets.

It was reasoned that on every thrust stroke the cylinder is pushed oval; then it rebounds to a less pronounced oval in the direction of the crankshaft axis. This vibration, coupled with chemical attack, was cited as the cause of cooling jacket erosion. The vibratory motions of the metal's surface eject products of metal-water corrosion, leaving a fresh surface open to renewed corrosive attack, it was implied.

Vibration studies suggest that the firing impulses and piston slap that cause the cylinder distortions correspond with major resonant frequencies of cylinder liners.

Suggestions for lessening cavitation-type attack included reducing sleeve deflection, reducing water velocity, coating sleeves with protective finishes, making liners of copper-chromium gray iron, and using inhibitors such as soluble oils in cooling water. Oil-type inhibitors cut down heat transfer ability slightly. But they are effective in stopping corrosion. And they don't cause dermatitis, as chromate-type inhibitors are reputed to do.

Specifications SAAB 93

General

Overall length	157⅛ in.
Overall width	61½ in.
Overall height	57⅛ in.
Wheelbase	98 in.
Turning radius	18 ft
Dry weight	1734 lb
Track, front and rear	48 in.

Engine

Cylinders	3
Bore	66 mm
Stroke	72.9 mm
Displacement	748 cc
Compression ratio	7.3/1
Maximum bhp	37.5 bhp @ 5000 rpm
Maximum torque	52.1 lb-ft @ 2000 rpm
No. of bearings	4

Transmission

Clutch	single disc, dry
Gears	helical
Ratios	16.74/1
	8.31/1
	5.10/1
	20.46/1 (reverse)

Chassis

Suspension .. Coil springs and hydraulic telescopic shock absorbers.

Brakes ... Hydraulic, four-wheel. Double brake cylinders on front wheels.

Wheels .. Rim width: 4 in. Radius 12 in. Tubeless tires 5.00 × 15 in.

Steering .... Rack and pinion.

Electrical system .... 12 v

Fuel system .... Down-draft carburetor. Electric fuel pump. 36 litre tank capacity.

Displayed at SAE

Swedish Car

SAAB 93 has a 3-cyl, 39-hp, 2-stroke engine.

A cutaway version of the SAAB 93, a two-door, front-wheel drive passenger car, made by the Swedish Aircraft Co., Linkoping, Sweden, was exhibited at the Summer Meeting in Atlantic City. Features include a 3-cyl engine which can develop 38 hp at 5000 rpm and a maximum torque of 52 lb-ft at 2000 rpm. The engine is mounted longitudinally forward of the front axle. Power is transmitted through a single dry disc clutch via a free wheel to the gearbox behind the front axle.

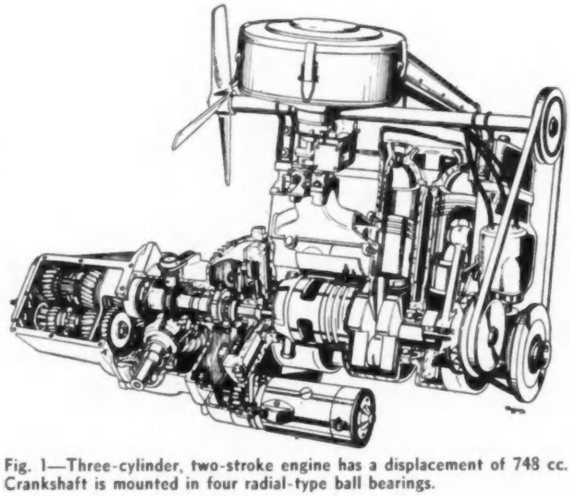


Fig. 1—Three-cylinder, two-stroke engine has a displacement of 748 cc. Crankshaft is mounted in four radial-type ball bearings.

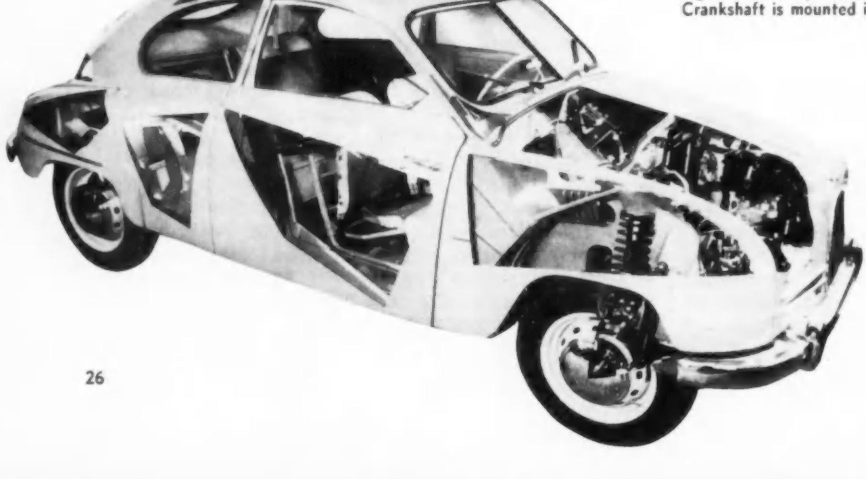


Fig. 2—Almost every detail of construction is visible in this intricately cutaway model. Swedish Aircraft Co. is awaiting American reaction to this show model before beginning mass production.

Specifications Jaguar XK-140

General

Wheelbase	102 in.
Tread, front	51 in.
rear	50.5 in.
Tires	6.00 × 16 in.
Curb weight	3135 lb
Overall length	14 ft 8 in.
Overall width	5 ft 4½ in.

Engine

Cylinders	6
Bore	3.27 in.
Stroke	4.17 in.
Displacement	210 cu in.
Compression ratio	8/1
Maximum horsepower	210 hp @ 5750 rpm
Maximum torque	213 lb-ft @ 4000 rpm

Transmission

Gear ratios	3.54/1
	4.83/1
	7.01/1
	11.95/1

Four speed synchromesh with optional overdrive.

Chassis

Suspension .... Front: Independent, transverse wishbones, torsion bars, and telescopic shock absorbers. Rear: Half elliptic springs controlled by telescopic shock absorbers.

Brakes .. Hydraulic, self-adjusting.

Steering .. Rack and pinion. Adjustable steering wheel.

Fuel system .. S.U. electric pump from a 16¾ gal tank.

Electrical system .... 12 v

Summer Meeting

Jaguar XK-140 MC Roadster

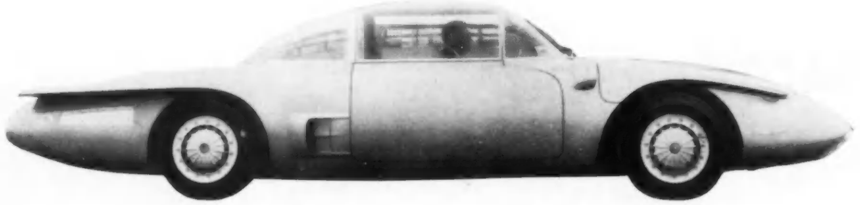
Jaguar XK-140 MC has a 6-cyl, 3½-liter engine which can develop 220 hp.

THE Jaguar Roadster that was displayed at the SAE Summer Meeting in Atlantic City is a direct descendant of the XK-120. Its 3442 cc engine has twin, overhead, high-lift camshafts driven by a two-stage duplex roller chain. Cylinder block is made of high grade chrome iron; cylinder head of high tensile aluminum alloy. Combustion chambers are hemispherical. Pistons are aluminum. It has twin S.U. horizontal carburetors with an electrically controlled automatic choke.

Fig. 1—The Jaguar XK-140 has new wrap-around bumpers, and re-designed overriders.

At the Summer Meeting . . .

GM's XP-500 car has streamlined chassis designed specially for its free piston engine.



THE CHASSIS of the XP-500 (See SAE Journal, June, page 60) was especially designed for the "Hyprex" free piston engine which powers it. The left side frame is large enough to house a 3½-in. insulated pipe which conducts exhaust gases from the gasifier in front to the turbine in the rear. (See Fig. 1.) The right frame sill is used to conduct hydraulic power tubing and electrical lines from the rear to the front of the car.

Because the engine has a small overall height, cross members can be placed across the engine compartment to tie the side frames together, thereby stiffening the frame. A standard automobile fuel tank is in the rear trunk of the car.

The body was designed to take advantage of the absence of a transmission housing hump on the front toe boards and of the driveshaft to the rear of the car.

The five-stage turbine in the rear of the car smooths out the power pulses from the four rapidly reciprocating gasifier pistons. The exhaust gas from the turbine is discharged underneath the trunk of the car through a short single pipe. No muffler is used.

The power output from the turbine is sent through a gearbox having a reduction ratio of approximately 7/1.

The gear box is bolted directly to the front of the transmission. Since the front elements of the transmission are running whenever the gasifier is in operation, certain accessories such as the electric generator, power steering, and water pumps are driven directly from the transmission. Because of the time involved in designing a completely new transmission, an available four speed unit is used.

The differential is bolted directly to the rear of the transmission. Naturally this means that the rear wheels are independently suspended to allow the mass of the turbine gear box, transmission, and differential to be fastened solidly to the chassis.

XP-500 has no rotating shaft for driving an engine fan, water pump, generator or other accessories usually driven by a fan belt in a conventional automobile. Instead, a high pressure hydraulic pump is operated from the car's rear-end transmission unit.

Hydraulic tubes lead through the right frame sill to the car's hood where a hydraulic motor turns the radiator fans and water pump. General Motors has found this system to be very efficient over a wide range of horsepower requirements.

Like the Firebird II, the XP-500 chassis is made of reinforced plastic. The XP-500 also has similar suspension system, steering mechanism, and rear wheel drive as the Firebird II. (See page 49.)

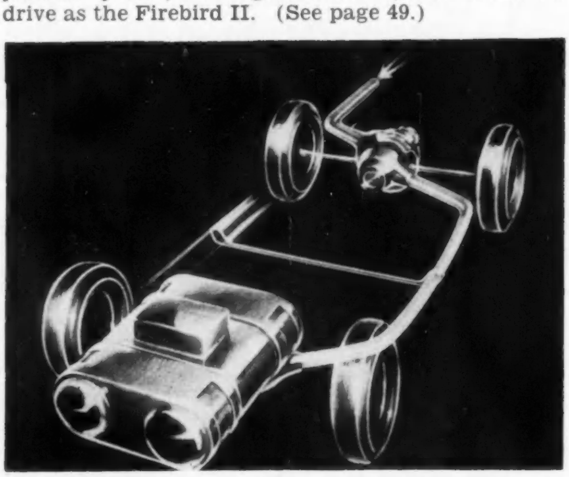
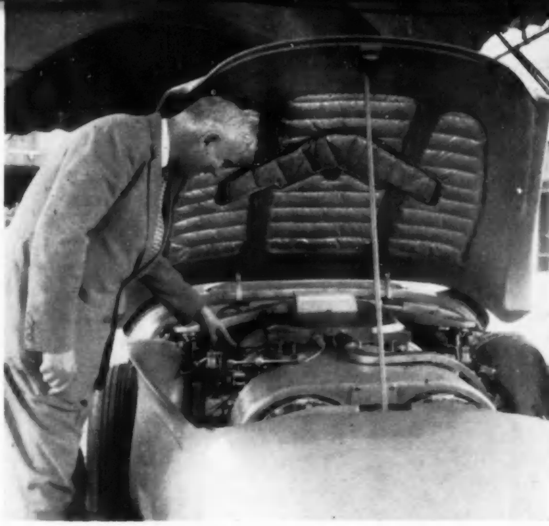
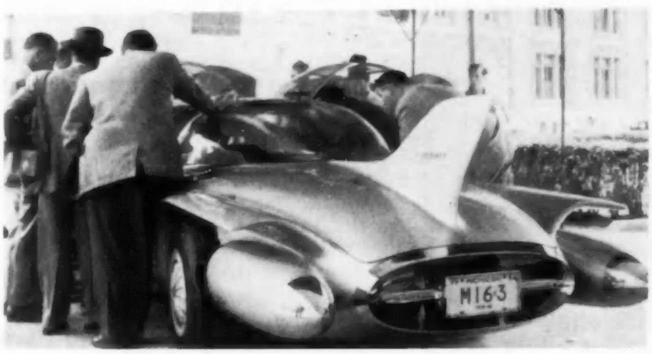


Fig. 1—The XP-500 chassis was designed to take advantage of the split powerplant arrangement of the "Hyprex" engine. Gasifier is in front; turbine and transmission are in the rear. Exhaust gases are piped through the left frame sill; hydraulic lines through the right sill.



FREE PISTON ENGINE on display during the meeting is examined by A. F. Underwood, GM Research Staff, whose paper on the engine is the subject of a feature article beginning on page 60 of the June SAE Journal. The engine is mounted in a chassis similar to the Firebird II chassis.

THE FIREBIRD II chassis and its gas turbine powerplant was on display during the meeting. SAE Past-President W. S. James is giving it a close look. Papers on this chassis and turbine, presented at the meeting, are the basis of a feature article beginning on page 48 of this issue.



SAE MEMBERS inspect the Firebird II gas turbine car. This new GM experimental model was the subject of two technical papers presented at the Summer Meeting. (See story beginning on page 48 of this issue.)

Met Section Chairman R. M. Cherryholmes Views Foreign Cars Displayed at Meeting

THE SAAB 93 lightweight car made by Svenska Aeroplan Ab (Swedish Aircraft Co.) of Linkoping, Sweden. There are details about its design on page 26.

THE JAGUAR XK-140 is built in England. It has a 6-cyl, 3.5 liter engine with a twin overhead camshaft. More about the Jaguar design appears on page 27.

President and Mrs. George A. Delaney

The President and his Lady at the HAWAIIAN FESTIVAL

Golf Chairmen

Mrs. Edwin H. Scott was chairman of the Women's Golf Tournament; Mr. Edwin H. Scott was chairman of the Men's Golf Tournament.

Skeet Chairman and Champion

W. W. Schafer was chairman for the Skeet Tournament—and champion skeet shooter, too.

1500 Work and Play At Summer Meeting

THE HAWAIIAN LUAU AND FESTIVAL was arranged by a Committee under the chairmanship of Mr. & Mrs. George Liddell (above). Others on the Committee were: Mr. & Mrs. Ralph Albright; Mr. & Mrs. E. N. Hatch; Mr. & Mrs. Jack E. Cole; and Mr. & Mrs. J. R. Splitstone.

SOME 1200 engineers came to the 1956 Summer Meeting to the Chalfonte-Haddon Hall in Atlantic City to exchange technical ideas by way of sessions, committee meetings, and informal conversations. Along with them came nearly 300 of their wives and daughters to enjoy the boardwalk, the bathing, and a series of special events-for-the-ladies.

All joined together in the big Hawaiian Luau and Festival which capped the climax of social events on Wednesday evening. And all enjoyed the welcome to the Meeting provided by the Sunday afternoon reception staged again this year by the Society's Metropolitan Section.

Golf, skeet-shooting, and other sports attracted many of the engineers in the afternoons, following morning and evening technical sessions. Many others, however, found themselves with committee schedules which tied them up throughout the day every day.

The Hawaiian party was among the most successful of SAE's recent social events. It started with a Hawaiian-food buffet, continued with exhibitions by hula dancers . . . and ended with an evening of pleasurable ballroom dancing by all who attended. Serving on the committee for arrangements for the Hawaiian Festival with Chairmen Mr. & Mrs. George Liddell were: Mr. & Mrs. Ralph Albright; Mr. & Mrs. E. N. Hatch; Mr. & Mrs. Jack Cole; and Mr. & Mrs. Jack Splitstone.

The Metropolitan Section Reception on Sunday this year featured a safe-driving contest. It was conducted by means of two machines which tested the driving ability of the more than 400 guests. Depth perception, spacial relationships, and braking reaction were measured . . . and prizes were awarded to the "best drivers."

Winners were: Mrs. E. Ryan; Mrs. J. S. Collman; Mrs. Dorothy Robbins; R. B. Emery; S. W. Blanton; and R. A. Randall.

In charge of arrangements for the Reception and contest under the chairmanship of Sid Tilden, Jr. were: C. M. Larson, T. L. Preble and M. Gould Beard.

The men's golf championship this year went to Robert G. Wingerter by a one-stroke margin over Frank Farrell, last year's champion. Both Farrell and Wingerter have won the SAE golf championship on numerous previous occasions, but this is the only recent year in which both have been competitors. Wingerter's winning 36-hole total was: 77-71-148. Farrell had: 74-75-149.

Mrs. Paul Ackerman won the Ladies' 18-hole medal play Golf Championship with a 97.

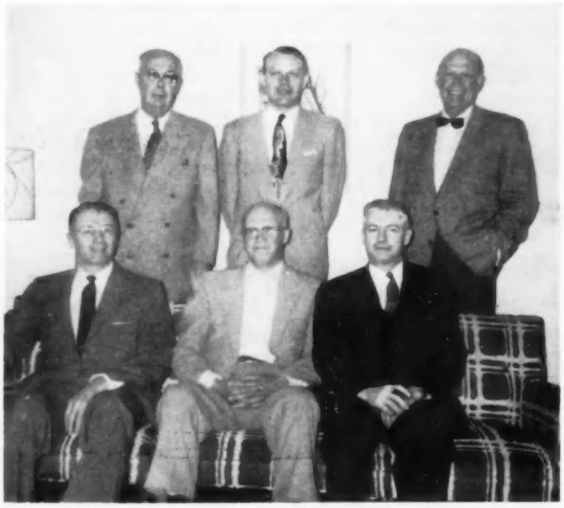
Skeet Chairman W. W. Schafer emerged as winner of the tournament, as well as its arranger. Next came R. H. Albrecht.

SAE MEETINGS COMMITTEE CHAIRMAN EARLE S. MacPHERSON got Council approval to hold the 1957 (Spring) Aeronautic Meeting at the Hotel Commodore for the first time. This New York gathering has previously been at the Statler. The 1957 dates are April 2-5.

CHAIRMAN EDWARD N. COLE (right) and committee-member W. F. Ford discuss proposed revisions in SAE Sections Procedures at a meeting of the Executive Committee of the SAE Sections Committee.

C. R. LEWIS, Chrysler Corp., (center) has been named chairman of SAE's Nuclear Energy Advisory group in place of the late A. L. Pomeroy. Newly expanded to permit more intensive coverage of its assignment to keep SAE abreast of nuclear development of possible interest to its membership, the advisory group now includes A. A. Kucher, Ford Motor Co., (left) and L. R. Hafstad, General Motors Corp., (right). Lewis reported his group's plans to the June 7 Council Meeting.

JOSEPH T. WENTWORTH (center) and WAYNE A. DANIEL (right) received the 1955 Horning Memorial Award for their paper entitled "Flame Photographs of Light Load Combustion Point the Way to Reduction of Hydrocarbons in Exhaust Gas." It was adjudged the best paper on the mutual adaptation of fuels to internal combustion engines presented before SAE in the year 1955. Award Committee Chairman C. J. Livingstone (left) made the presentation at the technical session sponsored by the Fuels & Lubricants Activity on Monday morning, June 4.



SAE PAST-PRESIDENT C. G. A. ROSEN heads a new informal group to explore possibilities for bringing into the SAE bloodstream more technical information and ideas from overseas sources. He undertook the assignment at the request of 1956 President G. A. Delaney. During the Summer Meeting he got ideas from some members assembled informally to discuss the subject. Among those at the informal session were: Left to right—sitting: W. Paul Eddy, Rosen, and Delaney; standing: F. P. Zimmerli, Robert R. Burkhalter, and Maurice A. Thorne.

D. N. Frey

Associate Director, Scientific Laboratory, Engineering Staff, Ford Motor Co.

Based on paper "New Alloys for Automotive Turbines" presented at SAE Annual Meeting, Detroit, Jan. 10, 1956.

New Alloys for Automotive Turbines

A start has been made in developing strong, low-cost, non-strategic, high-temperature alloys for automotive gas turbines.

THREE new classes of low cost, high-temperature alloys are being developed for use in ground vehicle gas turbines:

- Iron-base Cr-Mn-N austenitic alloys
- Iron-aluminum ferritic alloys containing up to 16% Al
- Cast ferritic alloys containing up to 12 Cr and minor amounts of Ti, V, Mo, and W.

Ground vehicle turbines can't use alloys developed for aircraft turbines because the aircraft alloys cost too much and, in some cases, require too much of scarce elements.

Table 1 shows the high alloy components of a hypothetical 300-hp gas turbine for a ground vehicle, the kind of materials of which they would likely be made, the quantities, and the prices that car builders might afford. The total high alloy material cost should not be much more than $100 if the gas turbine is to be competitive with the piston engine even in its more expensive applications to ground vehicles. That means that individual alloys must be relatively inexpensive. If, for example, high-temperature alloy forging billet and casting

Table 1—Alloy Costs of an Automotive Gas Turbine

Type of Material	Use	Finished weight, lb	Estimated maximum cost, $ per lb	Maximum cost per engine, $
A. Very thin ferritic stainless sheet	Heat exchanger	55	0.65 (0.002 in. sheet)	35.75
B. Ferritic stainless sheet	Moderate-temperature, high-stress ducts; high-temperature, low-stress parts	48	0.30 (sheet)	14.40
C. Austenitic stainless sheet	High-temperature, high-stress ducts	45	0.45 (sheet)	20.25
D. Austenitic high temperature alloy forgings	Compressor turbine rotor; other parts	14	0.85 (forging billet)	11.90
E. High temperature alloy castings	Compressor turbine blading; other parts	10	0.90 (into the mold)	9.00
F. Stainless alloy castings	Power turbine; other parts	30	0.20 (into the mold)	6.00
	TOTAL	202 lb		$97.30

Alloying Elements Are Expensive

Alloying element	Cost per pound contained
Cobalt (97-99%)	$2.60-2.67
Nickel, electrolytic	0.645
Molybdenum	1.46
Vanadium	3.10
Tungsten	3.45
Manganese, electrolytic	0.30
Aluminum, pig	0.225
Chromium	0.365

shot cost $4 per lb—which is typical of some aircraft turbine alloy costs—the 24 lb required would take up almost the entire cost allotted for materials.

Just as cost must be controlled, so must consumption of scarce alloying elements needed for military use. So Ford has set limits to the amount of alloys to be used in the gas turbine:

a. Cobalt not to exceed 5% in the compressor turbine blading alloys, and none elsewhere in the engine.
b. Nickel not to exceed 50% in the compressor turbine blading and not to exceed 5% in other hot rotating parts, and none elsewhere in the engine.
c. Tungsten, vanadium, and molybdenum not to exceed 3% in hot rotating parts and none elsewhere in the engine.

It appears that if (b) is adhered to then about 7.2 lb of nickel per engine would be used. This is well within alloy cost and availability limits.

Manganese Austenitic Alloys

Present gas turbine designs call for compressor turbine rotors and blades, and high-temperature, high-stress ducts to be made of forging, sheet, and casting alloys that are capable of high stress service in the 1150 to 1400 F temperature range.

As a substitute for alloys with large nickel content, high nitrogen, chrome-manganese steels look promising. Typical composition ranges are 0.2–0.7% N, 14–18% Mn, 14–18% Cr, and up to 2% Mo. These alloys at room temperature have high yield and tensile strength and excellent ductility, even after cold-working. At 1350 F the creep rupture properties of Cr-Mn-Mo-N steels are comparable to commercial alloys containing 16% chromium, 25% nickel, and 6% molybdenum.

To avoid gassing when casting these alloys (due to nitrogen evolution) centrifugal casting can be used. (Pressure melting and casting has been successfully tried but costs too much and is too complicated a method of adding nitrogen to the Cr-Mn steel.)

The typical 100 hr rupture life of both radial and circumferential coupons of centrifugally cast nickel-free, Cr-Mn-Mo-N austenitic steel at 1350 F is 28,000 psi, which is equivalent to a wrought Cr-Mn-Mo-N steel of the same composition.

For larger ingots a process similar to low-carbon rimming steel practice is used. The gas holes formed during ingot solidification are not found to be detrimental so long as they weld shut during hot rolling. This method also increases the ingot-to-slab yield, especially if the ingots are mechanically capped.

These high-nitrogen, manganese austenitic steels appear to be adequate for certain sheet steel ducts (Type C, Table 1) and compressor turbine rotors (Type D, Table 1). However, for compressor turbine blading, stronger more complex alloys are needed.

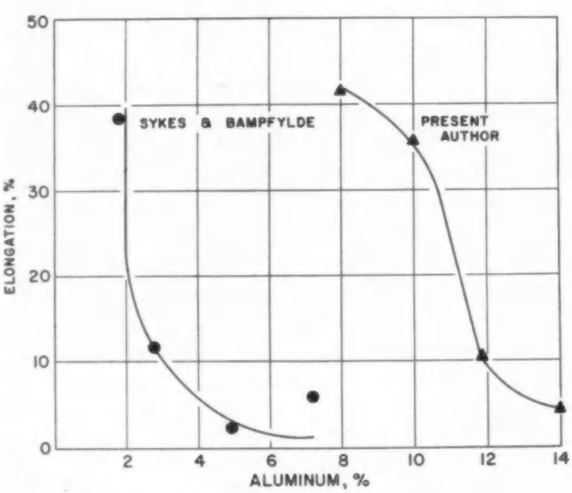


Fig. 1—Recent research has shown that by carefully controlling alloy composition, melting procedure, and fabrication techniques, more than twice the amount of aluminum previously considered maximum can be added to an iron-aluminum alloy without impairing ductility.

Iron Aluminum Alloys

For moderate-temperature, high-stress ducts, and high-temperature, low-stress parts (Type B, Table 1) such as burner can assemblies and nozzle guide vanes, a corrosion and oxidation-resistant alloy is needed. It must also be amenable to welding and cold-forming.

Iron base alloys with relatively high aluminum content seem to fit the specifications. These alloys, in fact, have spectacular resistance to oxidation. A typical 18-8 stainless steel will swell and blister after a few hours exposure at 2300 F, but an iron base alloy with 14% aluminum remains practically unaffected after 80 hr.

At 1800 F or more, at least 8% aluminum is required to resist oxidation appreciably. Unfortunately alloys containing more than 5% aluminum have been until recently brittle at room temperature.

Recent research has shown that by carefully controlling alloy composition, melting procedure, and fabrication techniques, up to 10% aluminum can be added before ductility is seriously impaired. (See Fig. 1.) With this amount of aluminum the alloy can resist oxidation adequately up to 2150 F.

To reduce brittleness vacuum melting was initially tried and the oxygen content of the alloy was reduced by adding carbon with no more than 0.03% residual during high vacuum melting. This can reduce the amount of oxygen in the alloy to about 0.001% in 10 minutes and still retain high impact strength and ductility. Carbon reduction is much

Table 2—High-Creep Strength, Low-Alloy, Ferritic Wrought Steels

Heat designation	C	Cr	Mo	V	Ti	W	Al	B	Commercial name
W-7	0.25	1.25	0.5	0.85					17-22 V
W-8	0.25	1.25	0.5	0.85				0.02	
W-9	0.25	1.25	0.5	0.85	0.25			0.02	
W-10	0.25	2.25	0.5	0.85		0.65			H-40, HGT 3, Hykro V 80
W-11	0.15		0.5	0.35	0.25				Mo-V-Ti (Glen's alloy)
W-59	0.15	1.25	0.8	0.35	0.15				
59	0.15	1.25	0.8	0.35	0.15		0.8		
W-60	0.28	12.0	2.5	0.5		1.5			422 M

simpler and less costly than using hydrogen deoxidation.

With careful control of melting procedure, air melting in conventional equipment has given comparable results in small heats at less cost than vacuum melting. Adding about 3% titanium or silicon will increase creep-rupture life at moderate temperatures.

Thus, it appears that ductile and workable simple iron-aluminum alloys with about 10% Al can be produced economically in sheet form for very high-temperature, low-stress parts such as combustion can liners. High-stress parts operating at temperatures up to 1150 F can also be made of Fe-Al alloys. Aluminum content must be at least 10% for adequate hot strength.

Cast Ferritic Alloys

For stainless alloy castings to be used in the power turbine (Type F, Table 1) alloys that can withstand temperatures in the moderate temperature range (up to 1150 F) are needed. Table 2 lists several high-creep-strength, low-alloy ferritic steels that were melted and tested in the cast and heat-treated form. Several are used commercially in wrought form. Between 1100 and 1200 F the cast alloys have the same stress rupture properties as the wrought alloys, as shown in Fig. 2. (One exception is the Cr-Mo-V alloy (heat W-7) where cast properties are inferior, probably due to heat-treatment.)

Of those alloys containing less than 5% total alloy content, it was found that a Mo-V-Ti composition (heat W-11) had the greatest strength. To prevent oxidation at high temperatures, Cr was increased to as much as 3%. However this decreases strength. Small aluminum additions, (about 0.8%) when carefully made, have little effect on strength. However, much more Al decreases the strength.

If boron is added to the Cr-Mo-V steels (heat W-7), strength is increased.

In the 12% Cr group of alloys the most promising is 422 modified (422 M). The cast properties, with those of the wrought material are given in Fig. 2 D.

Additions of 0.01% and 0.04% B decrease the stress rupture properties of this alloy. Titanium additions have little effect.

To insure a reasonably stable structure, tempering is done at 1250 F (for 6 hours), which is above the proposed maximum operating temperatures of the turbine. Normalizing and solution temperatures have a large effect on the stress-rupture properties. Generally with these alloys, the best treatment is to normalize at 2100 F and to follow with a solution treatment at 1950 F. With the high temperature normalizing treatment, a more homogeneous alloy is obtained, and upon further treatment a better distribution of the carbide is obtained. High temperature solution treatments give a more acicular ferrite, a structure which is often associated with improved creep resistance. High solution and normalizing temperatures are particularly important in the alloys bearing titanium or boron.

Increasing solution temperature improves stress-rupture properties of the 12% cast Cr alloy. 2100 F is about optimum. No measurable difference in properties is noticeable as a result of tempering at either 1200 F or 1275 F.

Thus, it appears that cast and heat-treated Mo-V-Ti steel has excellent strength up to 1100 F, but would have marginal oxidation resistance in many turbine applications. The less economical

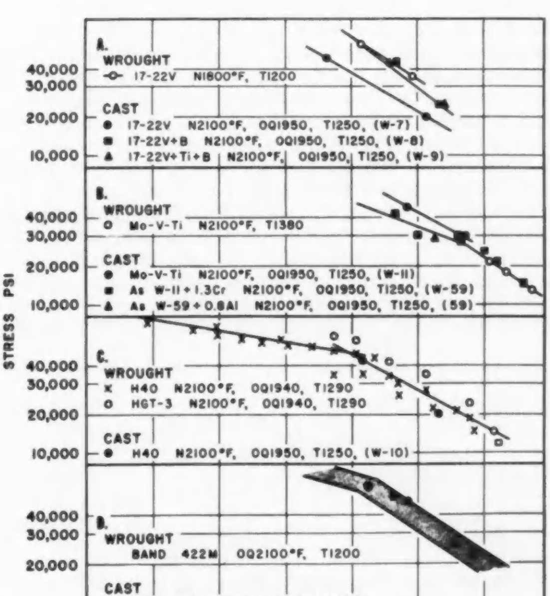


Fig. 2—Summary of rupture strengths of low-alloy steels.

422 M has about the same strengths at 1100 F but better oxidation resistance. The blades of a power turbine could perhaps be made of 422 M and the hub of Mo-V-Ti. The prime disadvantage of both these alloys is the rather difficult and expensive heat-treatments required to obtain the good high temperature properties.

Complete paper on which this abridgment is based is available from SAE Special Publications Department, 29 W. 39th St., New York 18, N. Y. Price: 35¢ to members, 60¢ to nonmembers.

Discussion

Question: What was the size of the air-melted Fe-Al alloy heat that had given as good results as a vacuum-melted heat?

Answer: We have made about 50 heats of 100 lb each. The melting practice information is not available. The alloy has to cost no more than 12¢ per lb or it's too expensive. One large vacuum melted Fe-Al heat was made of the 10% Al type and it has processed well.

Question: Do you still feel that brittleness is due to oxygen?

Answer: No. The evidence has become less clear and the variables are not clearly separated.

Question: We once added up to 5% aluminum to the ingot iron which produced so much hot shortness and brittleness that we had to drop the forging temperature to 1500 F. A yellow tinge was noted in the grain boundaries. Now silicon appears to reduce oxidation. Please comment.

Answer: If the temperature is high (about 2100 F) grain growth occurs, which gives poor workability. The Fe-Al and the Fe-Si systems are similar but the ductility of the Fe-Si systems falls off very rapidly at about 3% Si. Further research may eliminate this brittleness with silicon.

Convair Conversion . . .

. . . from piston engines to Eland turboprops has increased speed, range, flexibility, and overall performance.

Based on paper by **A. J. Penn,** Aero Gas Turbine Division, D. Napier & Son, Ltd.

CONVERSION of the Convair 340 from piston engines to Eland turboprops, as shown in Fig. 1, has provided a power output adequate to allow the all-up weight to be increased to its structural limit, brought an immediate weight saving of 2000 lb, and improved performance generally.

Comparison between the piston engine version and the Eland N.E1.6 engine version at 15,000 ft brings out some significant data. For this comparison the maximum all-up weight of 47,000 lb was taken for the Pratt & Whitney R-2800-CB-16 engine version and a typical cruising power of 1100 shaft hp was assumed. Using the Eland engine to the N.E1.6 rating, the maximum all-up weight is increased to 53,200 lb and a typical cruising power of 1750 shaft hp has been used. Under these conditions the Eland engine version can maintain the maximum payload of 12,900 lb up to approximately 1000 mile stage distance, whereas for the piston engine version, the payload falls to 10,000 lb for the same distance. Furthermore, the stage speed for the Eland version is 290 mph compared with 240 mph for the piston engine version at the stage distance of 1000 miles.

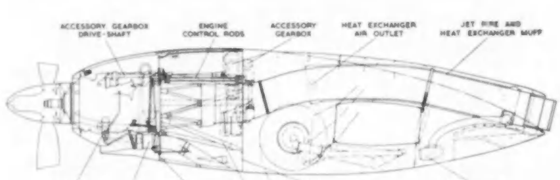


Fig. 1—Detail of the Eland turboprop installed as a replacement for piston type engines in the Convair 340.

By cruising the Eland-Convair 340 at 23,000 ft, the same maximum payload can be maintained up to a stage distance of 1200 miles with a stage speed of 280 mph. At a typical mean weight of 47,000 lb the aircraft has a substantially constant cruising speed of just over 310 mph for a range of altitudes from 8000 to 22,000 ft.

Engines for the Eland-Convair will be to the N.E1.6 rating, which has a take-off power of 3500 equivalent hp. This power cannot be fully utilized under standard day conditions and a torque restriction will be placed on the engine, equivalent to 3250 equivalent hp, by means of the maximum torque limiting device operated from the torquemeter. The reduction in take-off power which normally occurs with turboprops under high ambient temperature conditions will be, therefore, largely offset without recourse to water-methanol injection.

Due to the Eland engine's greater length relative to the piston engine, the plane of propeller rotation is well ahead of the forward bulkhead of the present passenger compartment. This bulkhead can be moved forward, at the expense of luggage space, to raise passenger accommodations from 44 to 48.

The Eland-Convair's ability to maintain the maximum payload over stage distances up to 1200 miles, makes it more flexible than the piston engine version. And it will cover both short and medium range requirements economically. (Paper "Eland Engine and Its Application to Civil Air Transport" was presented at SAE National Aeronautic Meeting, New York, April 10, 1956. It is available in full in multilith form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)

Recap Your Own Tires

A fleet operator's experience with do-it-yourself tire recapping

E. B. Ogden, Consolidated Freightways, Inc.

Based on paper "Operator's Experience With Repair and Recap of Truck Tires" presented at SAE Golden Anniversary Transportation Meeting, St. Louis, November 2, 1955.

SAVINGS up to 100% are possible if a fleet owner recaps his own tires instead of having it done outside. Of course, much depends on standardization of tire size, type of equipment, and volume. However, Consolidated Freightways saved $162,000 in 1954 by doing it itself.

Consolidated Freightways has 2,170 pieces of line equipment, 327 dollies, and 970 pieces of pickup equipment. Every working day we have about 21,000 tires rolling on the highway plus tires on city equipment. Average tire mileage is 3.5 million tire miles per day. Yearly mileage for 1954 was over 1.25 billion tire miles.

Our largest tire recap plant is in Portland, Oregon. This is supplemented by a tire recap and repair plant in Los Angeles. A Chicago plant recaps and repairs tires for Consolidated's eastern fleet, consisting of 181 tractors and 410 semis.

Average cost per tire mile, including recaps and labor was 8¢/mile in 1954. Since there are an average of 18 tires per combination, our total tire cost was 1.584¢/power mile.

We capped 13,500 tires in 1954. On the average we put on 2.7 recaps per carcass.

Average original tread mileage was 47,000 miles. Average mileage per carcass, original tread and recaps, was 156,000 miles.

Other operators may get greater mileage on the original tread. But we conserve the carcass so that we can cap the tire to the fullest extent. We use only 100 level tires in our operation since we have not been able to justify the extra cost for the extra heavy tread tires.

We also have an extensive preventive maintenance program. If tires are allowed to accumulate many small cuts through the tread, which allow water and gravel to work into the cords, the carcass quickly weakens and recapping it is uneconomical. We inspect tractor tires every 5000 miles and semis every 7000 miles for tread cuts. Cuts are repaired by vulcanizing rubber into the cut. We have several spot molds for this purpose. If there are many cuts in the carcass, the tire is put on a cap table with a smooth matrix and all cuts cured at once.

When the skid design is worn from the tread the tire is recapped. Any unusual tread wear that could be caused by mechanical defect is reported and corrected.

Front tires on the power unit are always new tires. They remain on the front until they show 1/8 to 3/16 in. tread wear. Then they are switched to the drive wheels. A recapped tire is never used on the steering axle of a power unit.

Tires are also checked for mating on semis and 4×2 and 4×4 power units. They are checked for matching and mating on 6×4 power units.

Matching is held to 1/8 in. diameter difference between front and rear axles on the same side of the vehicle and to 1/4 in. diameter difference on opposite sides. This is done for two reasons:

1. To reduce the friction between front and rear tandem axles which can cause loss of power as well as abnormal heating of the worm drive differentials.

2. To increase tire life. (Tires of a different diameter roll at different speeds. If they are geared to the same speed, as in a non-compensating tandem drive, they will slip and wear.)

A running mileage record is kept on each tire and posted each month. This eliminates any guess work as to which group of tires is performing the best.

For complete paper on which this article is based write SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.

Unusual Features of the

New American Motors

J. F. Adamson, C. E. Burke, and D. V. Potter,
American Motors Corp.

Based on paper "The New American Motors V-8 Engine" presented at the SAE National Passenger Car, Body, and Materials Meeting, Detroit, March 7, 1956.

IN ADDITION to developing an engine with high performance characteristics, American Motors designed its new V-8 engine to be adaptable to future displacement and compression ratio increases, for service accessibility and economical manufacturing, and for a high power/weight ratio.

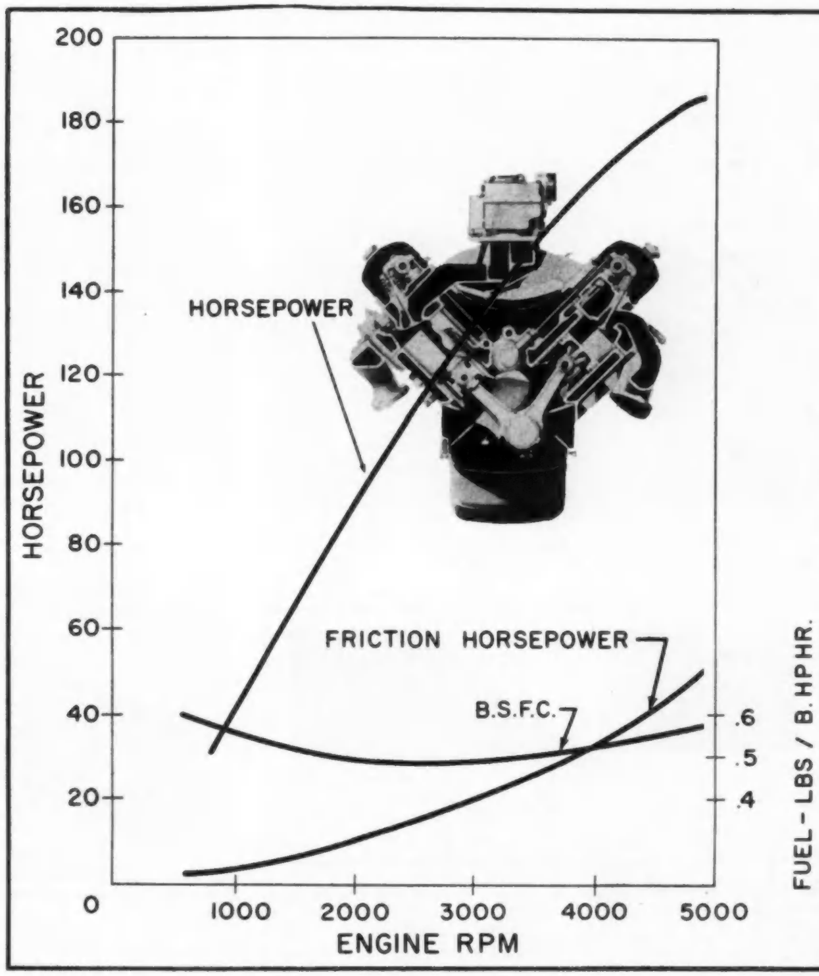
The compact engine has a low silhouette. This was achieved partially by choosing a short piston stroke which reduces height and width. The crankshaft counterweights are contoured to shorten the distance from the crankshaft centerline to the top of the block. Exhaust manifolds are carried below the port openings in the head and the intake port facings are held parallel to the cross-sectional centerline of the banks to further reduce the height of the carburetor flange.

Spark plugs are located well above the exhaust manifolds in a nearly vertical position for easier removal and installation. The generator is at the upper right side of the engine and outside the tappet cover. The distributor tang is long enough to mate with the oil pump shaft before the distributor gear mates with the camshaft drive gear.

The crankcase flange has been carried 2¾ in. below the crankshaft centerline to provide inherent stiffness and a good oil pan sealing flange. The flywheel housing mounting surface provides a wide and deep base for drive train mounting, and the 30 cylinder head bolts give a pattern that carries the gas pressure load evenly into the water jacket walls rather than into the cylinder bores. This arrangement reduces distortion and consequent abnormal wear of the bores, pistons, and piston rings.

The overall length of the block has been held to 23.02 in. by a careful consideration of coolant and loading needs. Windows have been cast in the main bearing webs where strength requirements showed it possible. As shown in Fig. 1 pockets have been cast on either side of the rear flange for further weight reduction. The right pocket nestles the starter close to the crankcase and permits the starter to be fastened to a light weight die cast aluminum flywheel housing. Thus several machining operations for a starter pad normally found on the block can be eliminated and considerable amount of cast iron can be omitted.

V-8



Combustion Chamber is Kidney-Shaped

The combustion chamber of the new V-8 is a wedge-type, kidney-shaped design. As shown in Fig. 2, it is similar to that used on American Motors recent six-cylinder engines. The intake gas is swirled by the design, and spark voltage requirements are quite low. Valves are not shrouded; therefore a high volumetric efficiency is obtainable.

Spark plugs are cooled by a considerable volume of water in the jacket surrounding them. They are located in the chamber to minimize the "drowning effects" of unvaporized fuel during cold starts.

Ports and Manifolds

Fig. 3 shows the basic configuration of the intake and exhaust port designs. Starting with the intake port opening in the head there is a smooth transition to the valve opening. A slight restriction in flow and consequent increase in gas velocity tends to develop a ram effect at the valve with subsequent increase in engine torque. Theoretically the gas velocity through the extra-large valve is very low.

Exhaust ports have also been designed to give balanced areas. Port size is increased as gases move away from the valve, to give sufficient scavenging and minimize back pressure. Exhaust manifolds are ample in area and provide for a smooth continuous flow of exhaust gases.

Crankshaft Is A Steel Forging

The crankshaft is a steel forging with five main bearings and six counterweights. Shaft length from the flywheel flange to the front edge of the sprocket shaft is 27.2 in., and a journal overlap of 3/4 in. provides increased stiffness.

All counterweights are cam-turned to realize fully every possible reduction in engine height. Too, the checks are chamfered to allow the contoured skirts of the pistons to nest closer to their respective crankpins when at bottom dead center. This in turn, shortens connecting rod length and further reduces engine height. Depressions are cast in the

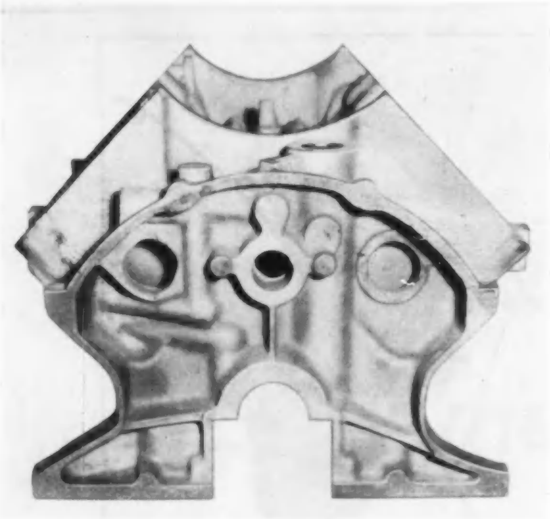


Fig. 1—Cylinder block rear face has pockets on either side of the rear flange for weight reduction.

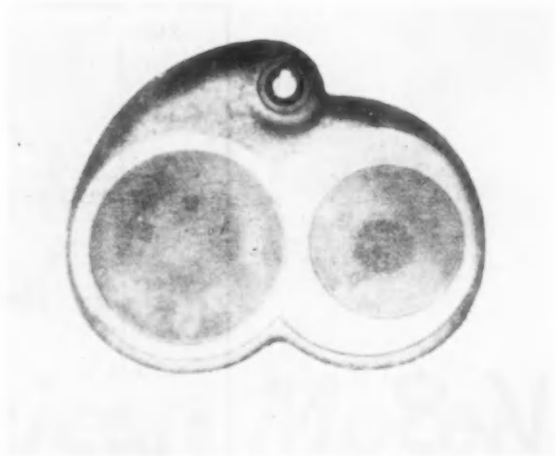


Fig. 2—Kidney-shaped, wedge-type combustion chamber gives excellent turbulence characteristics and, being cast, it requires little machining.

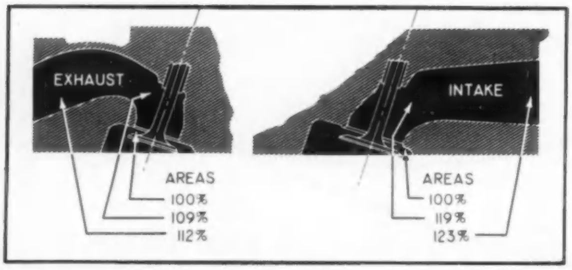


Fig. 3—The intake and exhaust port areas provide a smoothly balanced transition in relation to the valve opening.

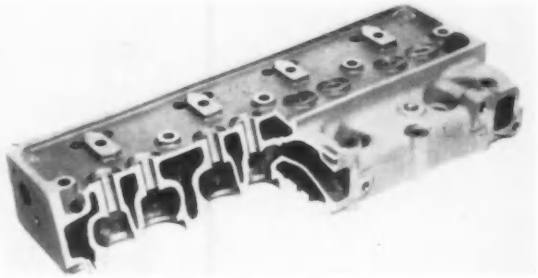


Fig. 4—Cut-away section through the valve centers in the head shows how water surrounds the valve seats giving longer life and trouble-free valve operation.

bottom jacket walls of the cylinder block to allow for clearance of the counterweights.

Bearings

Assembly simplicity and economy has been designed into the engine through the use of bearing interchangeability. All five bearing diameters are 2.499 in. and, with the exception of the front which is flanged to take crankshaft thrust, are interchangeable. Effective bearing area for the intermediate and rear main is 2.20 sq in., while the front is 2.08 sq in. Full 360 deg grooving is used to make the bearing halves similar and to insure adequate flow of oil to the connecting rod at the time of registration for cylinder wall lubrication.

Connecting rod bearing halves are also similar throughout. Bearing diameter is 2.249 in., and effective area is 1.935 sq in.

All bearings are micro-babbitt with steel backs.

Cooling System

Fig. 4 is a cut-away section through the valve centers in the head showing the way water surrounds the valve seats, giving longer life and less trouble during valve operation. Complete jacketing of the cylinders provides cooling for the entire length and circumference of the bores. The water pump contains a 4-in. diameter plastic impeller and is centrally mounted at the front of the engine. A drilled by-pass is provided in the water manifold for coolant circulation during cold starts and prior to the opening of the thermostat.

Lubrication System

The lubricating pump contains sintered iron gears and is an integral part of the rear main bearing cap. The pump is located well up towards the crankshaft centerline and allows placing the oil pan sump in a variety of fore and aft locations. This in turn gives a great amount of flexibility in locating the steering linkage. The pump is driven through a tongue and groove connection with the distributor shaft and is provided with an oil pressure relief valve.

From the pump the oil is forced through the filter and into the main oil gallery. Flow is then down to the $7/64 \times 5/16$-in. annular grooves machined in the camshaft bearing webs, and thence to the main bearings. Except for oil fed to the camshaft bushings, the main bearings are fed prior to any oil being bled off to another location. This assures that the

bearings farthest from the pump receive adequate lubrication.

Fig. 5 shows the intermittent lubrication of the chrome plated fuel pump eccentric. This time squirting of the eccentric is accomplished when the holes drilled in the front camshaft journal register with the camshaft bushing oil hole. Lubricant under pressure is then forced through a 3/32-in. diameter hole in the camshaft sprocket and onto the pump eccentric. Aside from this same spray which lubricates the timing chain, oil is picked up by the cast-in dam on the front cover and directed to the crankshaft sprocket.

Fig. 6 shows how the valve stem is lubricated during cold starts. The rocker arms have a milled flat which intersects the oil feed hole. The flat tends to break the surface tension of the cold oil oozing from the feed hole and causes it to flow freely to the valve end of the arm. Tests have shown that the time required to get oil to the valve stem during cold starts has been cut over 75% from previous designs. This milled flat also causes hot oil to spill over the sides of the arm and not to run down and over-lubricate the valve stems. Oil resistant rubber deflectors are fitted to the valve stems to prevent excessive oil being fed to the valve guides. These deflectors move with the valve stem, and allow oil mist to lubricate the stem and guide when the valve is in the closed position.

Piston and Rings

Following previous American Motors practice, the new V-8 uses aluminum alloy, steel insert, Autothermic pistons. These pistons have slippered skirts, are tin-plated, and have the piston pin boss hole bearingized after plating. This assures an accurate bearing area for the pin and helps prevent scuffing.

The pistons, shown in Fig. 7, are of the double slot design, and have three vertical ribs joining the head and bosses. These ribs support the bosses and tend to reduce deflections during the periods of high pin loading. The slipper type skirt is shaped to match

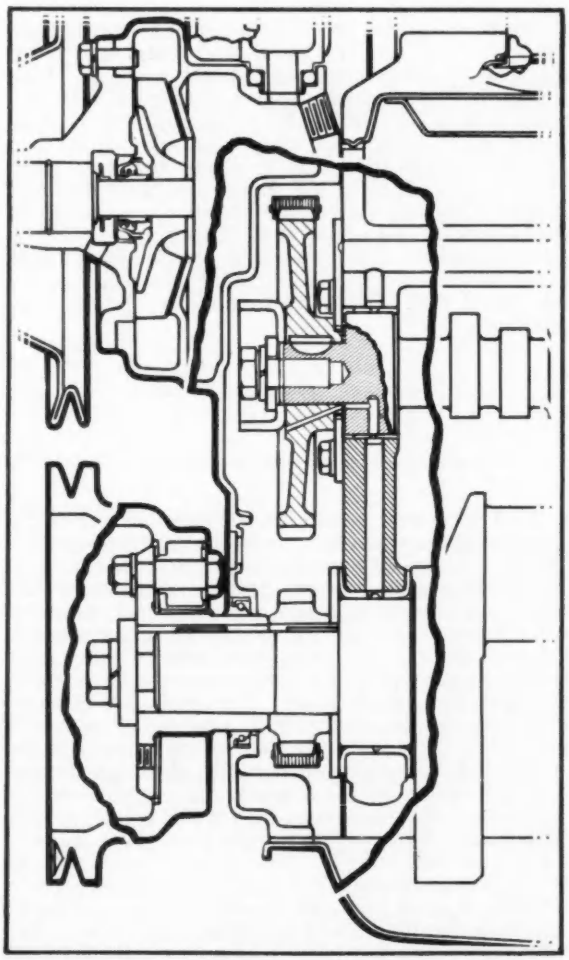


Fig. 5—Fuel pump eccentric and timing chain lubrication.

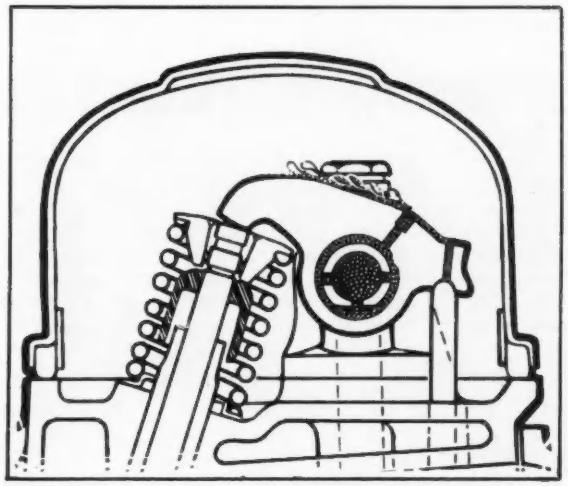


Fig. 6—Valve stem and rocker arm lubrication is aided during cold starts by a flat surface on the rocker arm.

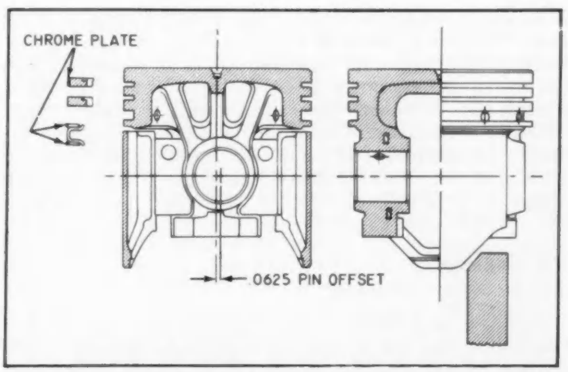


Fig. 7—Pistons have three vertical ribs joining the head and pin bosses, which support the bosses and tend to reduce deflections during periods of high pin loading.

American Motors V-8 Engine

Maximum Horsepower	190 hp @ 4900 rpm
Maximum Torque	240 lb-ft @ 2500 rpm
Friction Horsepower	34 hp @ 4000 rpm
Compression ratio	8/1
Bore	3½ in.
Stroke	3¼ in.
Displacement	250 cu in.
Overall Engine Width	22 5/8 in.
Overall Engine Height	14 5/16 in.
Overall Engine Length	27 23/32 in.
Weight Engine Complete (less transmission)	601 lb
Cylinder Block	160.9 lb
Crankshaft	62.8 lb
Cylinder Head (each)	49.5 lb
Exhaust Manifold (including crossover)	27.9 lb
Intake Manifold	27.8 lb
Front Cover	14.7 lb
Camshaft	10.2 lb
Connecting Rod Assembly	1.72 lb
Piston	1.13 lb
Valve Train (including lifter, pushrod, rocker arm, intake valve, valve spring, retainers)	1.09 lb
Electrical System	12 v

closely with the contoured counterweights of the crankshaft when the piston is at bottom dead center.

Three piston rings are used. The compression rings are 5/64 in. wide alloy iron with the top ring having a 0.004–0.007 in. thick, lapped chrome plating. The oil control ring is made up of two rails and a spring steel spacer. The rails carry buffed 0.0025 in. minimum chrome plating on their reacting faces.

The Valve Train

The camshaft is alloy iron with five bearings and is chain driven. All lobes carry a 15 microin. maximum finish and the cams are ground with a 0.001–0.002 in. taper.

Hydraulic lifters are used. Lifter bodies are hardenable iron with a face hardness of 54 Rockwell C and are lubrited for improved break-in. Pushrod sockets are case hardened steel.

Solid pushrods are ¼ in. diameter and are made of SAE 1060 cold drawn steel with spherical ends hardened to 50 Rockwell C. Overall length is 8.87 in., which assures a very rigid valve train component.

Rocker arms are cast pearlitic, malleable iron and are extremely short to further reduce valve train deflection.

Intake valves, which are made of Silchrome No. 1 steel, have 1.787 in. diameter heads and 30 deg seat angles. The exhaust valves are of two piece construction with the head and upper stem made of SAE 2112M steel.

Because of the compactness and lightness of the valve train, spring forces can be kept relatively low. This, in turn, reduces lifter face stress and eases lifter and camshaft wear problems.

Due to the relatively large valves used with the present displacement, valve timing can be kept to conservative values. A top center valve overlap of only 23 deg has proved to be ample for high speed breathing and resulting high end performance. This small overlap gives the engine excellent idling characteristics and "low end" output.

For complete paper on which this abridgment is based write SAE Special Publications Department, New York, N.Y. Price: 35¢ to members; 60¢ to nonmembers.

Discussion

E. M. Crankshaw,
The Cleveland Graphite Bronze Co.

Bearing loads for the entire speed range of this engine are well within the capacity of the microbabbitt bearing. As bearing loads increase in the future it will be quite possible to use other bearing materials; namely the intermediate duty type. Then if loads should climb still higher, they can be easily accommodated on the trimetal type bearing, which is the highest duty bearing on the market today.

Vincent Ayres,
Saginaw Division, Eaton Mfg. Co.

The use of hydraulic valve lifters and the knowledge that the valve train will operate satisfactorily without pump-up or other disagreeable effects at speeds over 5000 rpm is not an easy accomplishment. Good high speed motion can be obtained in an L-head valve gear with high lift cams having sharp changes in acceleration due to the inherent rigidity of the parts. We have photographed velocity and acceleration oscilloscope diagrams at high speed that appear to be almost theoretical. However, an overhead valve train may have five to ten times the amount of deflection, and this lowered valve gear frequency may permit severe vibrations to occur in the operating speed range. The amplitude of these vibrations is greater with a cam which abruptly moves the valve train than when the contour is designed to produce smooth motion. Gradual changes in acceleration or rate of loading are most desirable for a cam in overhead valve systems. Hydraulic lifters cannot be used in a valve train that will not behave at high speeds. The cam contours used in the American Motors V-8 engine were developed to produce gradual changes of acceleration in order to minimize the high speed valve train vibration. The vibration which does occur is of low amplitude which is within the tolerance of the hydraulic lifter.

How One Aircraft-Engine Builder Applies

Precision Machining

T. G. Conway, Lycoming Division, AVCO Mfg. Corp.

Excerpts from paper "Machining Techniques of Precision-Machined Parts" presented at the SAE Wichita Section Utility Aircraft Meeting, Wichita, Kan., Nov. 13, 1954.

THE aircraft industry is finding that building the planes of today and tomorrow is requiring extensive use of precision machining. Already, it is being applied to all sizes and kinds of parts from the smallest components of electronic capacitors to the largest parts in huge aircraft. The company that does not learn its techniques will not be successful maker of these planes for long. Consequently, we would like to discuss some of the techniques we have found helpful in manufacturing the following aircraft-engine parts:

1. Compressor discs.
2. Compressor rotor disc coupling.
3. Pinion cage for reduction gear unit.
4. Cylinder barrels.
5. Crankcase.
6. Crankshaft.

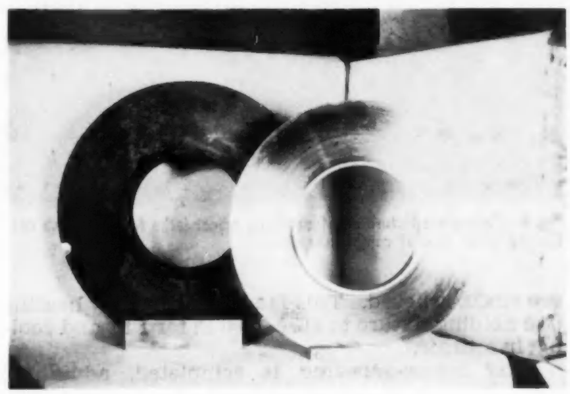


Fig. 1—Rough forging and finished compressor disc.

Compressor Discs

Compressor discs for jet engines have been one of the toughest parts to machine and hold the tolerances required that I have seen in a long time. The job has, however, been running very smoothly for sometime and rejects are at a very low level.

Fig. 1 shows a rough forging, with a finished piece for comparison, to illustrate the amount of stock that has to be removed. These discs range in diameter from 20 to 22 in. They require machining all over the contours on both sides, finishing up with a web thickness tapering from approximately ½ in. at the hub to 0.065 in. at the outside edge of the disc. The material used is SAE 9840, hardened to Rockwell C 26–32, which is not particularly easy steel to machine.

The first operation performed is rough boring the inside diameter, rough forming and facing the outer hub, as well as back facing the inner hub. This operation is performed on a standard turret lathe.

Having rough bored the hole and rough faced both hubs, we rough form the inner hub and rough the outside diameter of the flange. This puts us in a position to start machining the contours—which is what makes this job a problem.

Using a standard vertical turret lathe, we found that the forgings were of sufficient size and stability at this stage so that conventional spring jacks, supports, and equalizers could be utilized on roughing operations, employing the use of mechanical cams and followers, for the contours. Fig. 2 shows the type of fixture used in roughing the outer face, and due to the variation in forgings it is necessary to adjust the supports slightly for each piece.

Fig. 3 shows the rough contouring of the opposite face. The fixture used is similar to the one used in the previous operation, with the exception that we have a machined surface to locate on for support instead of the rough forging.

After the discs are rough-machined all over, they

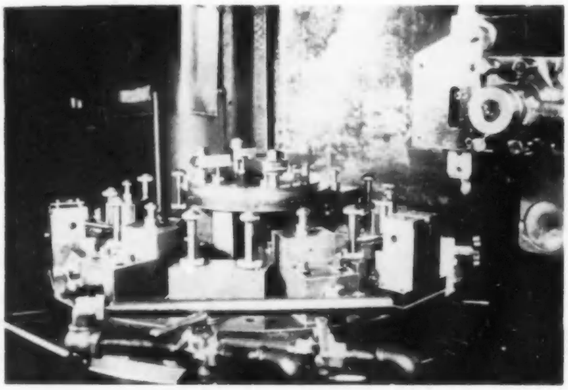


Fig. 2—Fixture on 36-in. Bullard vertical turret lathe for roughing outer contour of compressor disc.

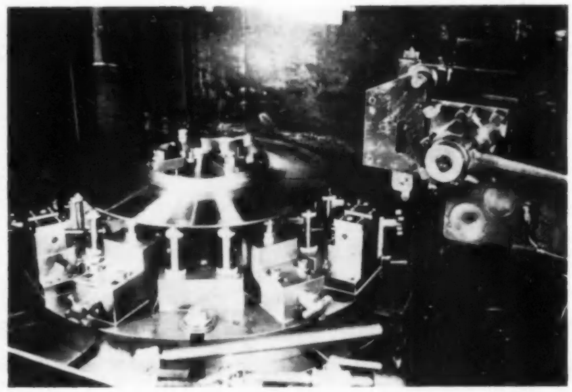


Fig. 3—Rough contouring inner face of compressor disc.

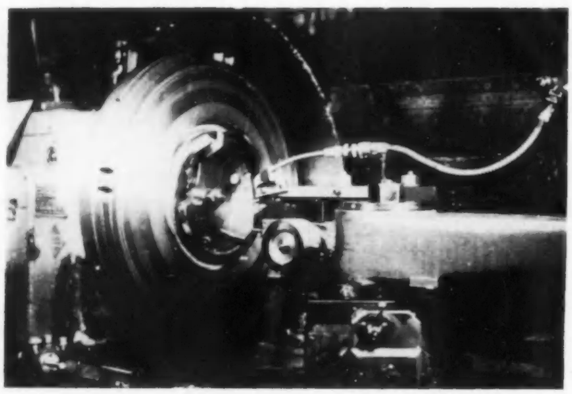


Fig. 4—Face-plate fixture on Monarch air tracer lathe for semifinish contouring outer face of compressor disc.

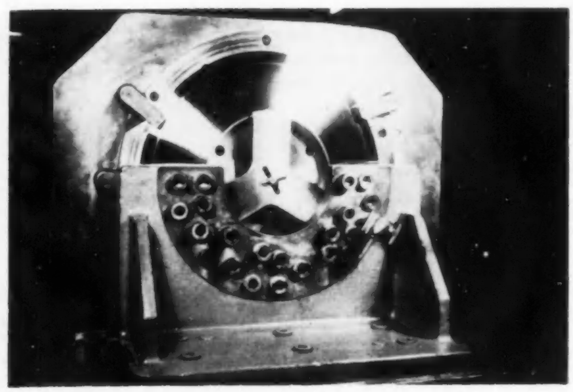


Fig. 5—Finished compressor disc in checking fixture.

are stress-relieved. This is accomplished by heating in a holding fixture to 1075–1100 F, for 1 hr and cooling in still air.

After stress-relieving is completed, additional stock is removed using the same procedure and sequence employed before the relieving of stresses, as the part is still rigid enough and the web thick enough to use conventional methods.

The setup shown in Fig. 4 is that used for semifinish contouring the outer face. It was recognized that, without proper support, tool and clamping pressures would distort the piece. This distortion would be transmitted from side to side. Air tracer lathes were selected to finish-machine both sides, holding the 0.005–0.008-in. tolerances on this thin web section. A face-plate fixture, containing a cavity into which Cerro-matrix was poured, was used, with a semifinished machined disc applied to the front of the fixture to act as a mold. These face-plate fixtures were then mounted on the tracer lathe, and the Cerro-matrix machined to the contour of parts obtained in the previous operation. The matrix was relieved, as necessary, to eliminate a 100% bearing. This method of supporting and holding proved highly succesful, as not only has necessary support been obtained, but it has had a tendency to deaden vibration.

A rotary grinder with a magnetic holding fixture employing a ring for locating is used to finish-grind the inner flange face, holding the 32-microin. finish and the 0.0015 in. on the thickness.

An internal grinder is used to grind the hole and the outer hub face and, after all grinding operations are completed, the hole, the two hub faces, and the inner flange face at the outside diameter must all be square and parallel within 0.001 F. I. R. (as applicable).

At this point the outside diameter of the disc is finished, forming radii as required, and holding diameter to 0.002 tolerance, and also concentric with the hole within 0.002 F. I. R. At this point the part is complete and ready for inspection.

Fig. 5 shows the finished compressor disc in the checking fixture, which has to be held to tolerances of 0.005–0.008 in. on thickness at the 20 different check points on the contour, which vary from 0.50 in. in thickness to 0.065 in. at the outside diameter.

Compressor Rotor Disc Coupling

Fig. 6 is a view of a Gleason Revex used in machining the 120 serrations on the compressor rotor disc coupling shown in the foreground. In the initial setup for a very low production the roughing of the serrations was accomplished on a conventional milling machine. With increased requirements the

Fig. 6—Gleason Revex cutting serrations on coupling ring.

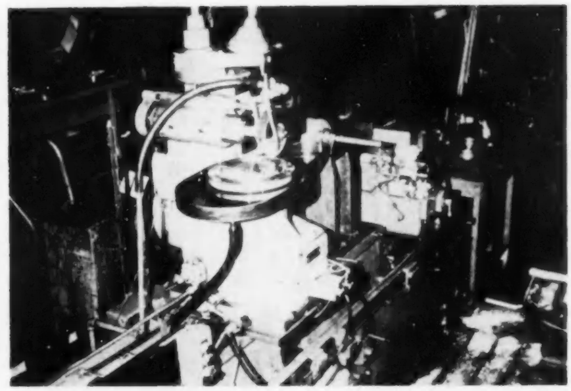


Fig. 7—Head of Detroit gear grinder in vertical position for grinding serrations on coupling ring.

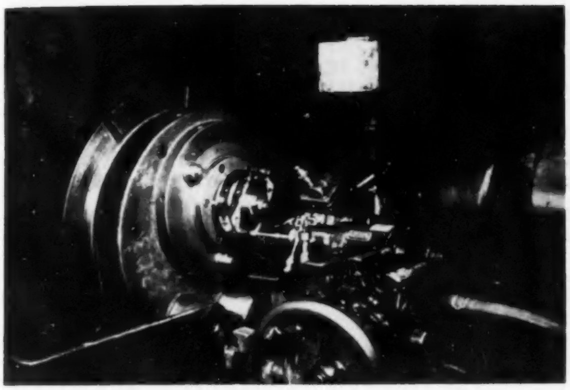


Fig. 8—Heald gap grinder grinding inside diameter of pinion shaft holes in pinion cage for reduction gear unit.

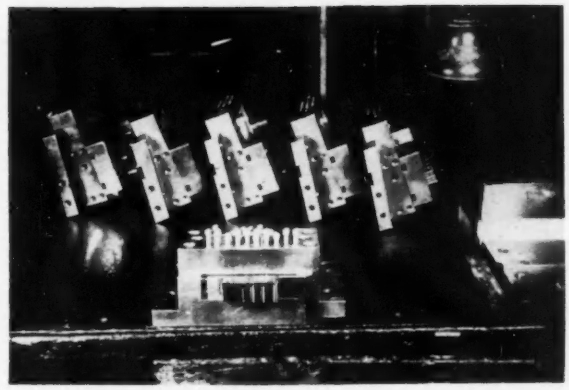


Fig. 9—Tool block with tools set for machining fins on cylinder barrel.

Gleason Revex was tooled up, increasing production by 800%.

Fig. 7 shows the gear grinder with the head in the vertical position for grinding these 120 serrations, which must be equally spaced within 0.002 in. on the face of a $10\frac{1}{4}$-in. diameter, and holding a 32-microin. finish and a 0.002-in. tolerance from opposite face to pitch plane of serrations. The indexing head of the grinder was removed and a subbase mounted on the machine table to adapt the head to a vertical position. The conventional indexing mechanism of the gear grinder provided for the 120 serrations.

Pinion Cage for Reduction Gear Unit

One of the most precise operations in the manufacture of the Lycoming engine is the finish-grinding of the six holes in the pinion cage for the reduction gear unit shown in Fig. 8. These six holes are for the shafts of the pinion gears and, as each pinion must bear its share of the load, these holes must be parallel with the pitch diameter of the splines to within 0.001 in. per in. of length and equally spaced to within 0.0005 in.

Using experience gained in developing a similar fixture for grinding the wristpin holes in the master connecting rod on our R-680 radial engine, we designed a counterbalanced index fixture for use on an internal sizematic grinder. This fixture consists of a base plate with the necessary counterbalance, and a rack-and-pinion-operated locating plunger, which is mounted on the machine face plate exactly on the centerline of the work spindle. On this base plate is mounted the index holding fixture that has six hardened index bushings, which are in the exact location of each of the pinion shaft holes, and have a splined pilot which locates in the drive spline of the pinion cage. The pinion cage is aligned radially by means of a removable locator plug, which goes through one of the semifinished pinion shaft holes into a blind bushing on the same centerline as one of the index bushings. After the part to be ground is clamped down securely, this locator plug is removed and each of the six holes is ground by indexing the work-holding fixture on the locating plunger in the base fixture. In order to keep the original accuracy of the fixture, it is so constructed that no coolant and grit can get into the indexing mechanism to cause undue wear.

Machining the fins on the cylinder barrels for our aircraft engine presented a very tough and expensive tooling problem. These barrels have 18 fins 0.025-in. thick with grooves of 7/16-in. deep, and inasmuch as it is only possible to average seven barrels per tool grind on this material and with thin tools, a

great deal of time was spent in setting the individual tools after each sharpening, which resulted in a costly loss in machine hours.

By designing a special tool block, finning tools, and a tool setting gage, we were able to save several hours a day in lost machine- and man-hours. This tool block (Fig. 9) is made with a keyway which locates the block for depth of cut on the tool holder on the lathe. Therefore, we made a setting gage, shown at the right in the illustration, which is similar to an angle plate. This angle plate has a hardened and ground strip on its vertical inside face parallel to a key which is a given dimension from the strip. When using this setting gage, the tool block is set on this key, tool bits are placed in the block, making sure everything is absolutely clean, and the cutting tips pushed gently up against the gaging strip; then the locking screws are tightened to hold the bits in place. At this point the block and tools are ready to be placed in operation on the lathe, with no further adjustment of tools. Another feature that saves a great deal of time setting up the tool bits is the design of the bits themselves. Since the fins are only 0.025-in. thick, in order to eliminate shims between the cutting tools, each bit is made 0.025-in. thicker than the groove between the fins, and the cutting lip is ground the correct width for the groove. When these tool bits are assembled in the tool block, each bit provides its own clearance for a fin. The wider tool bits for machining the holddown flange and the head stop ring are designed the same way so that there are no spacers or shims used in the tool block setup.

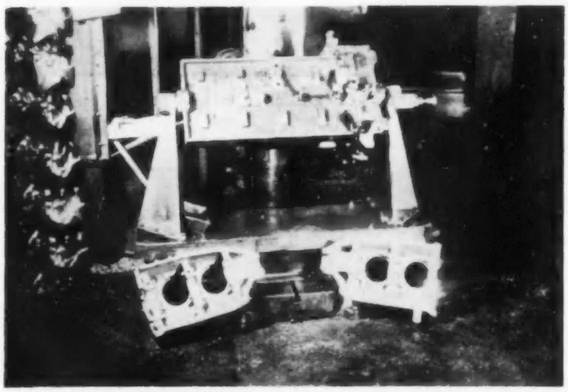


Fig. 10—Trunnion fixture on radial drill for drilling and reaming locating and dowel holes in crankcase.

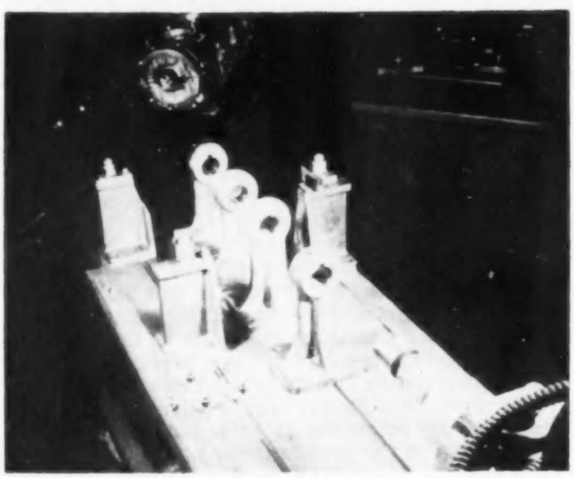


Fig. 11—Fixture on Rockford drill for boring main bearing holes in assembled crankcase.

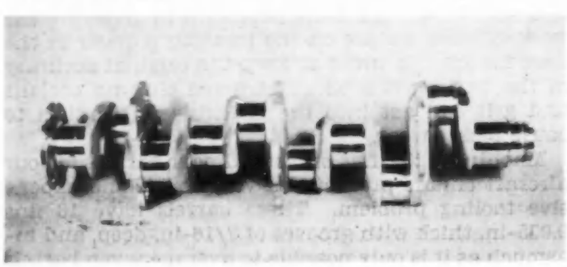


Fig. 12—Crankshaft used in 6-cyl opposed aircraft engine.

Crankcase

The crankcase of the Lycoming engine presented quite a problem from an economic as well as a machining standpoint. When the original crankcase line was set up, there were no special provisions for locating the crankcase in assembly or for performing the finish operations on the main and camshaft bearings. They were finished to approximately a 0.002-in. limit on the diameter in the halves, and being an intermittent cut it was very hard to hold size.

When these crankcases were assembled, they were put in a line reaming fixture with two locating bars, one in the main and one in the cam bearing roughed holes, then jacks were put under the crankcase and the assembly clamped. The main bearing bar was removed and the hole bored, one bearing at a time. When the mains were bored, a locating bar was put in and the bar that was in the cam bearings removed, and they in turn were bored. It was a slow, costly operation. After this operation was completed, all other operations were located in the main bearing bores, which made cumbersome fixtures and slow working conditions.

These operations were improved and speeded up by the addition of three locating lugs on one-half of the crankcase, which are milled at the same time as the mating faces.

Fig. 10 shows the drilling and reaming fixture, where the locator holes are put in at the same time as the dowel holes. The two halves of the crankcase are drilled and reamed on the same fixture. With this procedure the roughing of main bearing and cam bearings does not have to be held to a close tolerance and, when the two halves are put together in assembly, there are three lugs and two locator holes for all the fixtures on the assembly machining operations to locate from. This is possible since the three lugs are milled at the same time and on the same plane as the mating faces, which allows you to locate the horizontal centerline of the bearing bores. The two locator holes in turn locate the assembly sideways and for length, which tends itself to simple and accurate holding fixtures.

Fig. 11 shows the simple boring fixture made possible by using the lugs and reamed holes for locating. It also shows the support and alignment for the boring bar. The four capscrews shown in the left front

position are for the locator used in boring the 8-cyl crankcase. At present the machine is set up for the 6-cyl job.

Crankshaft

The crankshaft shown in Fig. 12 is used in our 435 6-cyl opposed aircraft engine. It provided an interesting subject in respect to nitriding and the resultant problems posed in machining. When we first started to nitride crankshafts for our aircraft engines, the main and crankpin journals were finish-ground before nitriding then, after the process, were polished with fine emery cloth to remove the white film and scale. However, we had difficulty holding concentricity and parallelism of the bearings from one end of the shaft to the other because of distortion during the nitriding process. After studying the problem, it was found that we could safely remove 0.004–0.006 in. from a nitrided diameter without any decrease in hardness or wearability. From the results of this study it was decided to finish-grind the main bearing journals after nitriding and continue the practice of polishing the crankpin journals. Since using this procedure we have had no trouble making main bearings concentric and parallel with each other. Also, the pin bearing journals, which take more punishment in the engine, have the slight advantage of the thicker nitrided case.

For complete paper (in multilith form) on which this abridgment is based, write SAE Special Publications. Price: 35¢ to members, 60¢ to nonmembers.

Cabin Pressure Control System . . .

. . . for transports relies on three pressure monitoring units to regulate outflow valve. Resulting control keeps passengers comfortable, is easy to operate, and requires only infrequent servicing.

Based on paper by **Everett H. Schroeder,** Kollsman Instrument Corp.

IN the Kollsman KS-54 cabin pressure control system, three pressure monitors are the sensing elements. The altitude monitor produces a voltage indicative of the deviation of the cabin altitude from the preset value. The rate-of-climb monitor gives a voltage proportional to the rate-of-change of cabin altitude. And the differential pressure monitor produces a signal when the cabin-to-ambient differential pressure approaches a preset limiting value. These voltages are combined, amplified, and used to control a relay which operates the motor of the cabin air outflow valve.

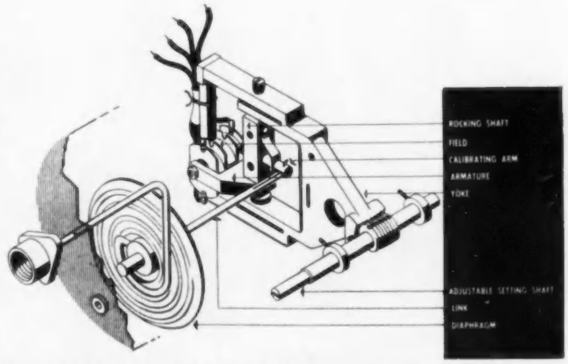
The flight crew has only two controls to set, one for desired cabin altitude and the other for the rate at which that altitude is to be reached.

The three pressure monitoring units operate on the same principle, but differ slightly. The schematic drawing shows a differential pressure monitoring unit. The pressure fitting feeds cabin pressure to the inside of the diaphragm. The vent feeds static pressure to the inside of the instrument case, where it acts upon the outside of the diaphragm. The diaphragm is attached to the rocking shaft by means of a link and calibrating arm. The link is attached to a temperature compensator on either the diaphragm center or the rocking shaft. As the diaphragm contracts or expands, the rocking shaft is turned.

Attached to the rocking shaft is a C-shaped iron armature. The field structure inside the armature carries four symmetrically wound coils connected in an inductive bridge. The field is mounted on the yoke, which turns in bearings concentric with the center of rotation of the rocking shaft. When the armature is centered on the field structure, the bridge is balanced and the output of the monitor is null. When the armature is moved, the inductance of one side increases, while that of the other side decreases. The result is an output voltage from the bridge. The magnitude of the output voltage is proportional to the distance of the armature from the center. The phase of the voltage reverses as the armature moves from one side to the other. The motion of the armature about the field structure is limited by two adjustable stops.

The yoke carrying the field structure is turned by rotating the setting shaft, on which is cut a worm engaging a sector of a worm wheel cut into the end of the yoke. There are non-jamming stops on the adjustment shaft which limit its rotation.

(Paper "Development of a Cabin Pressure Control System for Transport Type Aircraft" was presented at SAE National Aeronautic Meeting, New York, April 10, 1956. It is available in full in multilith form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)



DIFFERENTIAL PRESSURE MONITOR uses a Bourdon-type diaphragm to transform pressure differential to rotational movement of shaft. Shaft movement is converted into a voltage signal.

W. A. Turunen and J. S. Collman
Research Staff, General Motors Corp.

Based on paper "The Regenerative Whirlfire Engine for Firebird II" presented at the SAE Summer Meeting, Atlantic City, June 5, 1956.

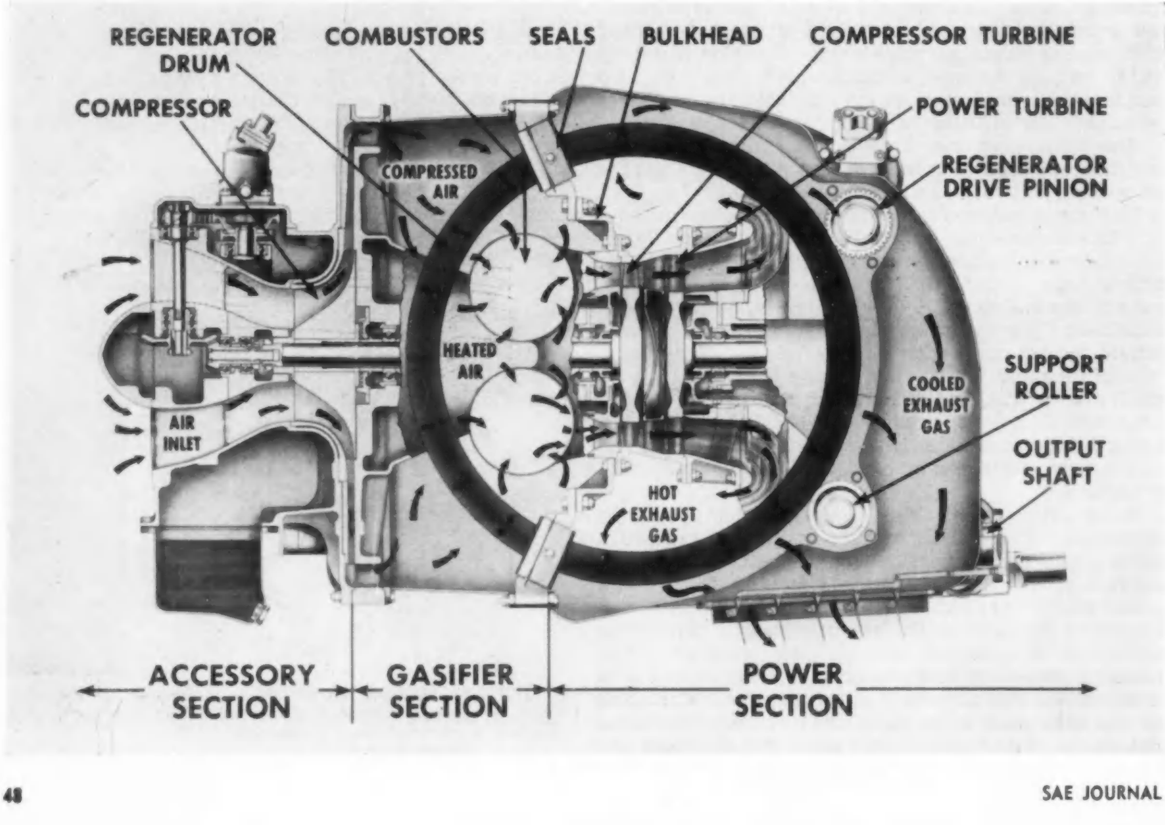
General Motors Firebird II's Engine

The GT-304 Whirlfire engine accelerates faster with less noise and 50% better fuel economy than the Firebird I installation.

MORE than 90 "paper engines" were evaluated by electronic computers before the GT-304 (Whirlfire) gas turbine engine was designed and produced for the Firebird II. Considerable effort was made to achieve the compact, well integrated power package shown below.

Air enters the radial flow compressor from the left. After passing through the diffuser, it is diverted 90 deg and discharged axially into a plenum chamber housing the regenerators, combustion chambers, and turbines. The plenum is divided into a high pressure and low pressure section by the seals and center bulkhead assembly. Two drum-shaped regenerators, rotating about a horizontal axis, pass from the low pressure or exhaust side of the plenum to the high pressure side through floating seals. The

Continued on Page 52



J. B. Bidwell and R. E. Owen
Research Staff, General Motors Corp.

Based on paper "The Experimental Chassis for the Firebird II" presented at the SAE Summer Meeting, Atlantic City, June 5, 1956.

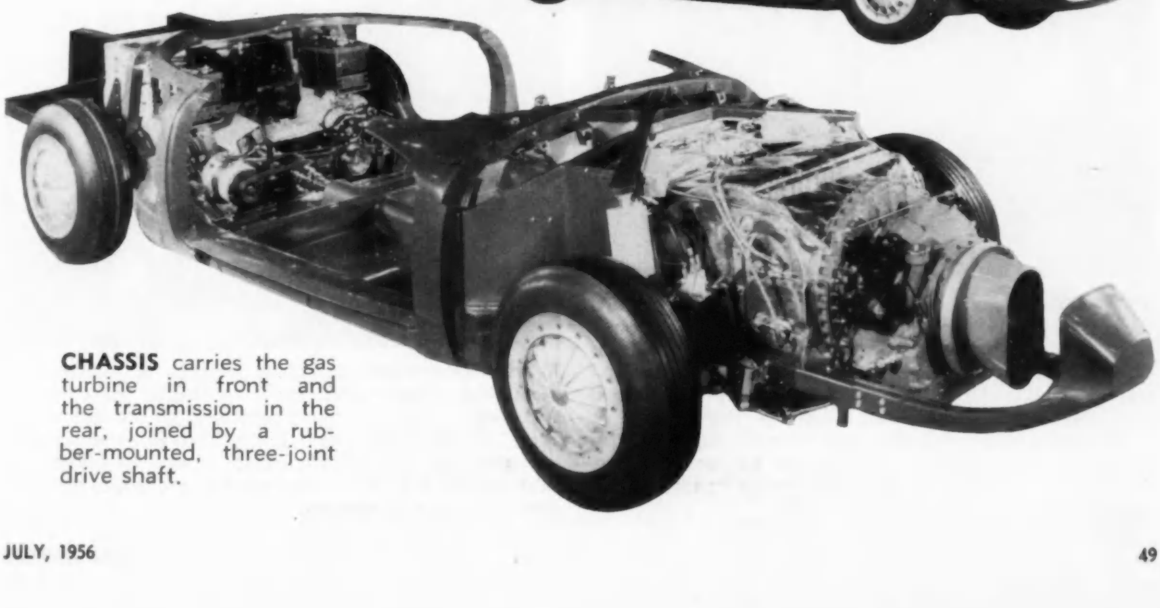
General Motors
Firebird II Chassis

Successor to the 1954 Firebird I, General Motors' new experimental gas turbine car has several novel engineering features

THE FIREBIRD II, in which the regenerative Whirlfire gas turbine engine is installed, is an experimental car designed to test engineering features for possible adoption in future GM cars. Besides the powerplant, which is described on the opposite page, these engineering advances include:

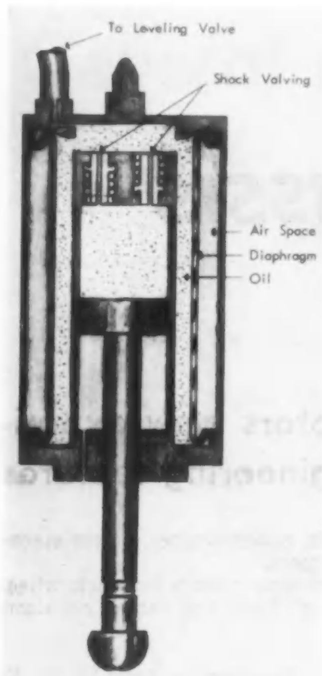
- A central hydraulic system that supplies power for levelling the chassis, power brakes, power steering, and windshield wipers.
- Independent suspension system for each wheel with air-oil springs that keep the car at constant height from the road.

Continued on Pages 50, 51, 52

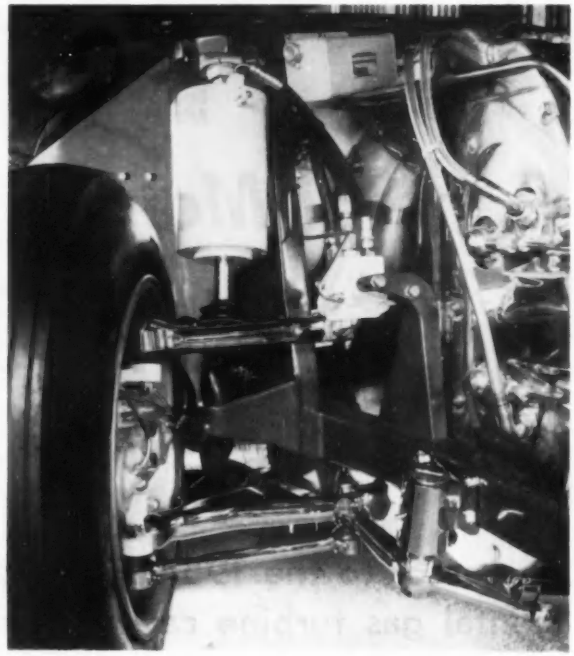


CHASSIS carries the gas turbine in front and the transmission in the rear, joined by a rubber-mounted, three-joint drive shaft.

About the
Firebird II Chassis . . .



AIR-OILSPRINGS are designed so that air is retained between the outer shell and a cylindrical rubber diaphragm. Pressure is transmitted through the oil from the top of the piston which supports the load. Leveling valve permits oil to enter or leave spring as required to maintain constant car height. The fixed air mass acts as the spring medium. An air pump is not needed. Oil pressure under load of four passengers is about 750 psi.

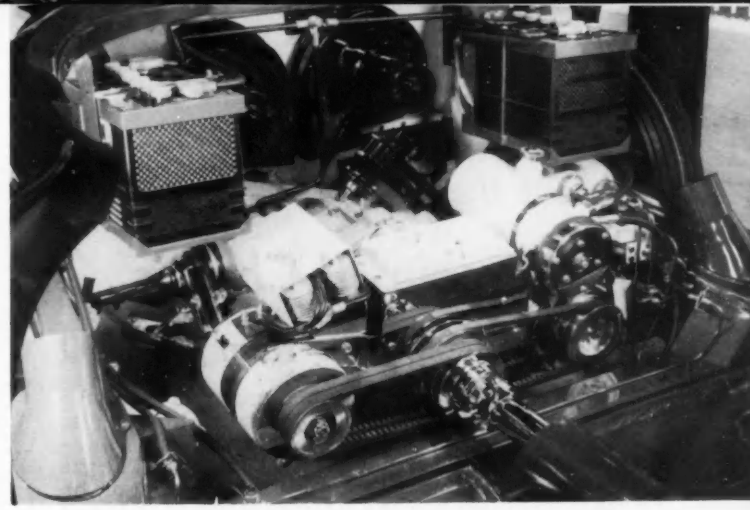


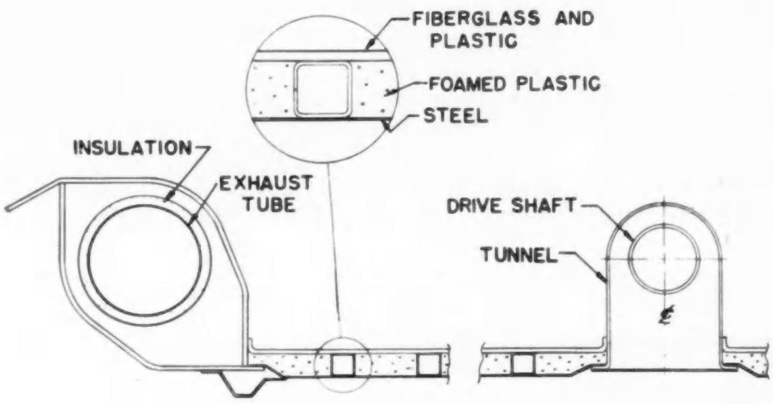
SHORT AND LONG parallel suspension arm arrangement is used which has its roll center at the ground. Integrated brake, knuckle support, and wheel make possible a low king pin inclination of 4 deg and 2¾ in. ground offset. Steel steering knuckles are supported in plastic coated balls which bear directly in ball seats machined in the aluminum arms. The spring reacts on the upper arm through another plastic coated ball and aluminum seat, which is protected from dirt by a rubber boot.

TRANSMISSION is mounted on a cross beam forward and on two arms which go over and under the suspension arms in the rear. Short drive shafts with two universal joints connect the wheels and the differential. A ball and trunnion joint is used at the inboard end. A single Cardan joint is used at the wheel. A cross member behind the rear wheels supports the rear of the transmission and the rear suspension arms (in white). The arms turn on Teflon coated bushings.

X-SHAPED, diagonal cross brace is continuous through the front dash. It is welded to the cowl bar and hinge pillar which is attached to the sill members. Shear panels add rigidity between the suspension arm supports and the pillar. Front air-oil springs bear against the cross brace on top and upper suspension arms on the bottom.

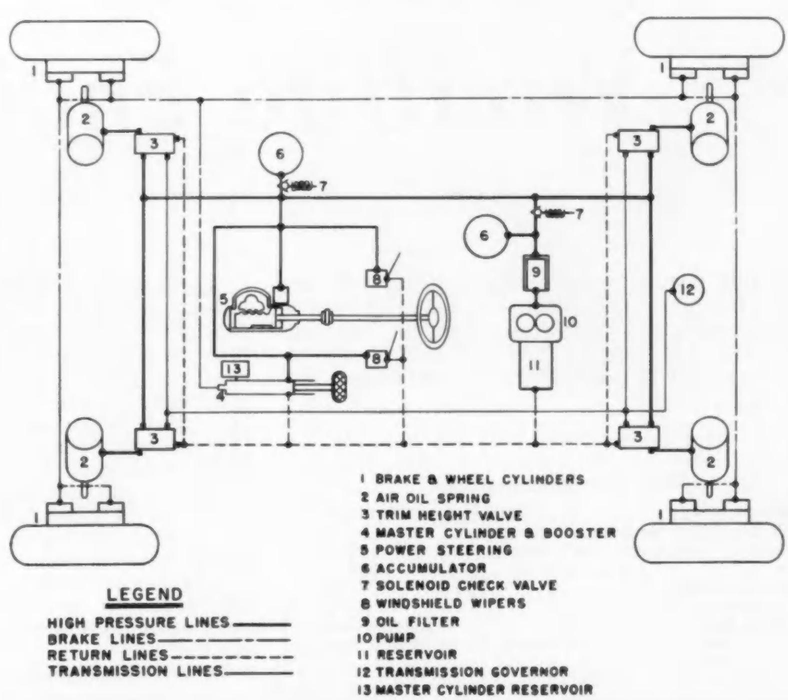
IN THE REAR the alternator, air conditioning compressor, and the hydraulic system oil pump are driven by the transmission input shaft. Batteries, blowers, and rectifiers are also behind the passenger compartment.





LARGE SILLS carry 4-in. stainless steel exhaust tubes from front to rear where they join exhaust outlets on top of the body behind the passenger compartment. The flat 1-in. thick floor contains square steel tubes which increase its rigidity and provide protected channels for wires, fuel, and hydraulic lines. Intermediate space is filled with plastic foam.

CENTRAL HYDRAULIC system uses type A transmission fluid. Pump operates whenever system pressure drops below 850 psi and bypasses when the pressure reaches 1100 psi. Two accumulators store energy to meet peak load demands.



About the

Firebird II Chassis . . .

continued from page 50

• Disc brakes with metallic linings and hydraulic booster. Brakes are cooled by vanes in the disc which pump air across the braking surfaces.

• Separation of engine and transmission. The gas turbine is in front; the transmission and most of the large accessories are mounted between the rear wheels.

The Firebird II was conceived as a high-speed, four-passenger vehicle for long-distance travel on smooth highways. It accelerates faster with less engine noise and uses about half as much fuel as the Firebird I.

The passenger space is located further forward than in present cars. The short distance between the centerline of the front wheels and the dash is made possible by the small 16-in. wheel diameter and the rear transmission position. Too, the front compartment floor is unobstructed by a transmission hump.

Chassis Specifications

Wheel base	120 in.	Front overhang	49 in.
Front tread	60 in.	Rear overhang	66 in.
Rear tread	57 in.	Cowl height	36.8 in.
Overall length	235 in.	Ground clearance	5.5 in.
Overall width	70.6 in.	Turning radius	26.7 ft
Overall height	52.8 in.	Curb weight (inc. fuel and oil)	5300 lb

An acoustic intake silencer, mounted forward of the engine, is an integral part of the body.

The wheels are made of cast magnesium and are chromium plated. The separate 16-in. diameter × 7.6 in. wide rim is sealed with a large O-ring to permit the use of tubeless tires. The wheel spokes and the rim flange act as a blower for cooling the brake disc. Three steel pins bolted to the inside of the wheel engage and drive the disc links.

For complete paper (in multilith form) on which this abridgment is based, write SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.

About the Firebird II's

Whirlfire Engine

continued from page 48

compressor discharge air passes radially through the regenerator drums picking up heat before entering the combustion chambers. The four, can-type combustion chambers, two on each side of the engine, are arranged parallel to the regenerator axis.

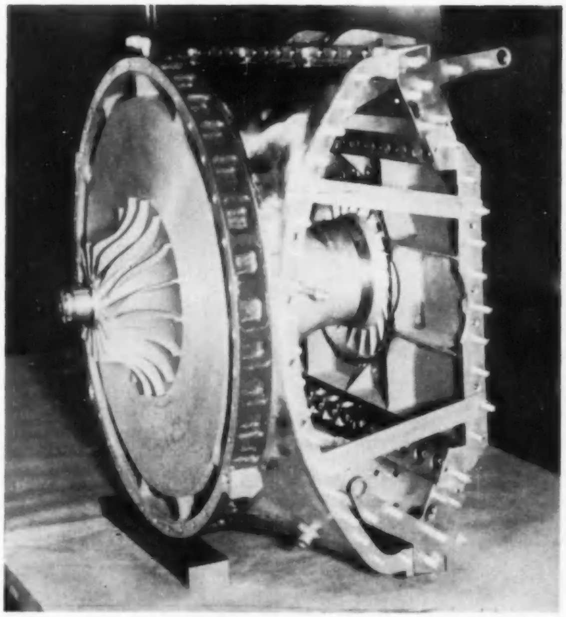
Whirlfire Specifications

Design rating	200 hp @ 35,000 rpm
Turbine inlet temperature	1650 F
Exhaust temperature (full load)	550 F
(part load)	250 F
Engine weight	850 lb
Regenerator weight	¾ lb/hp
Rated power turbine speed	28,000 rpm
with overspeed allowance	to 35,000 rpm

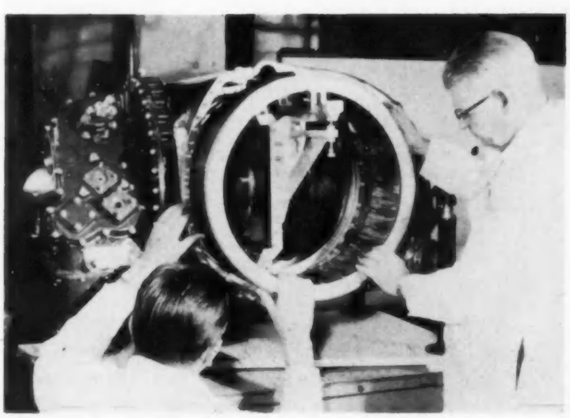
Fuel is sprayed into the chambers through nozzles located in the outer ends of the cans. The heated gas leaving the chambers is diverted into the turbine inlet annulus by symmetrical transition sections. The hot gas is expanded through two mechanically independent turbine stages located in the center cylinder. The first stage turbine drives the compressor and accessories, and the second stage turbine is connected to the vehicle wheels through reduction gears and the transmission.

Hot gas exhausted from the power turbine is diverted to the center part of the low pressure plenum. From there the gas passes through the regenerator drum, to which it gives up heat. The heat transferred results in a considerable reduction in temperature before the gas is exhausted to the atmosphere.

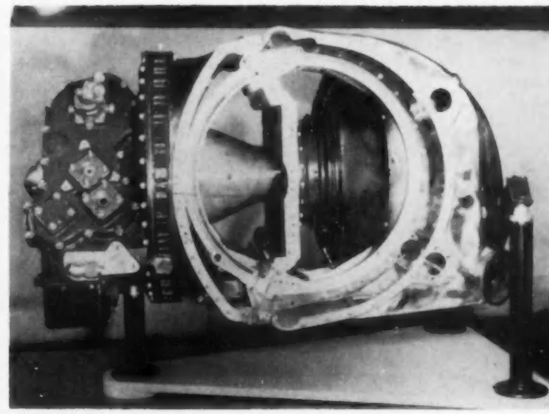
One of the important features of this integrated engine arrangement is the direct airflow path and



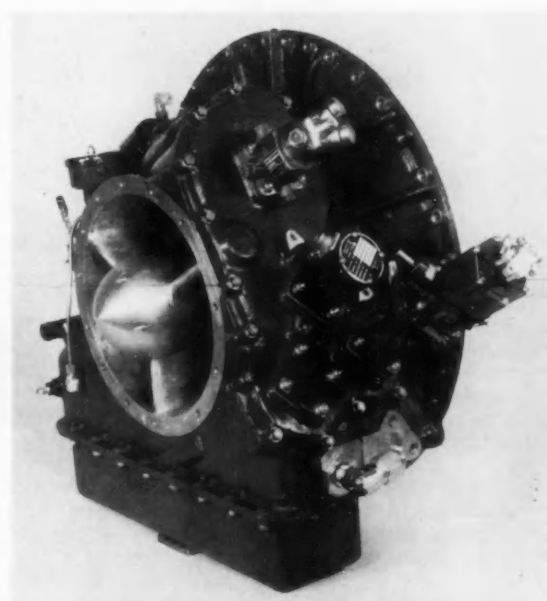
GASIFIER SECTION includes the gasifier turbine, compressor rotor, bearing housing, compressor discharge casing, and the bulkhead and seal assembly. The rear compressor housing is an integral part of the bearing housing. The compressor discharge passage around the circumference of the housing provides an exceptionally desirable compressor outlet condition. The sheet metal compressor discharge casing serves as a pressure vessel and as a structural component of the engine between the compressor housing and the bulkhead and seals, which separate the high pressure portion of the air plenum from the low pressure section. The gasifier turbine nozzle assembly is attached to the forward side of the bulkhead and on the turbine end of the bearing housing.



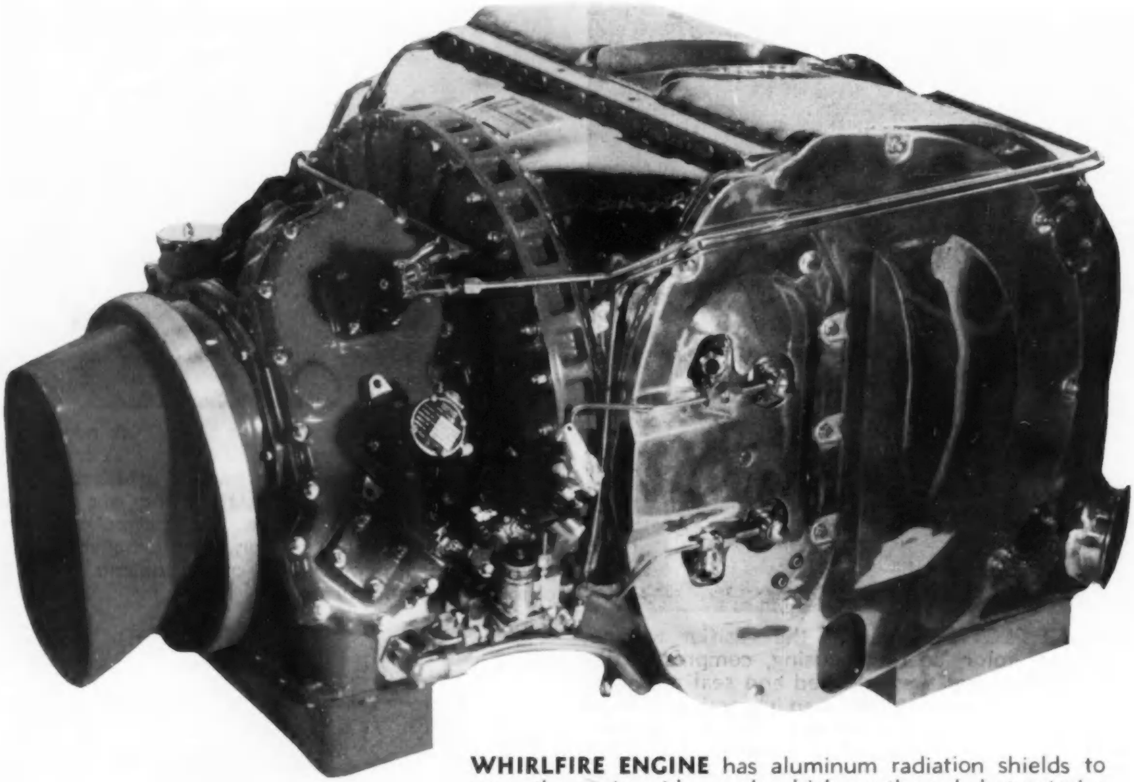
REGENERATOR DRUMS are supported by fixed roller shafts located in and supported by the exhaust housings. The geared rims of the drums engage pinions on the upper roller shafts to drive the regenerators from a hydraulic motor. Regenerator seal assemblies are movable to provide perfect alignment with the regenerator drums.



POWER SECTION includes the power turbine, reduction gears, and the exhaust housings. A mounting bracket with two mounting pads is attached to the rear of the gear case. Exhaust housings are attached on each side. The power section is attached to the gasifier and accessory section. An exhaust diverter prevents direct impingement of the turbine discharge onto the regenerator drums.



ACCESSORY SECTION incorporates the air inlet duct, the compressor front cover, the oil sump, and drive pads for the gasifier connected accessories. These include the automotive type starter, fuel pump and governor assembly, built-in lube scavenge and supply pump, and a fluid power pump for the regenerator drive motor. Power for the accessories is taken from the front end of the gasifier shaft through spiral bevel reduction gears. The lube pump assembly is located near the bottom of the housing within the oil sump. Oil goes to all parts of the engine including reduction gears and fluid power pump.

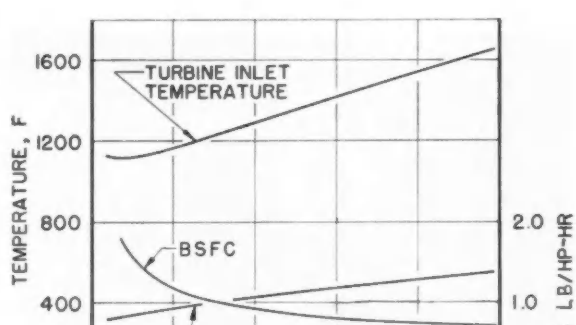


WHIRLFIRE ENGINE has aluminum radiation shields to cover the engine side panels which are the only hot exterior surfaces. The engine side covers complete the engine plenum enclosure and structurally tie the compressor housing, bulkhead assembly, and exhaust housings together.

complete absence of interconnecting ducts. The few number of bends in the airflow path and large plenum type air passages contribute to very low pressure losses.

Another important benefit derived from the engine arrangement is that no thermal shielding or insulation is required for the engine except on the circular regenerator end covers. Those parts of the engine which are exposed to, or contain, hot gases are confined within the inner diameter of the regenerator drums. The top, bottom, front, and rear surfaces of the engine are exposed to compressor discharge air or exhaust gas cooled by passage through the regenerators. Reduction of heat radiated from the engine lowers engine compartment ventilation requirements and results in slightly higher thermal efficiency.

One of the most suprising features of the GT-304 engine is the very low noise level. This is noticeable in the test cell as well as in the Firebird II installation. The regenerators are undoubtedly responsible for much of this improvement. The plenum type design with low air velocities, as well as the attenuating effect of the regenerator matrices, act as sound barriers to muffle the turbine exhaust noise. A very



CALCULATED PERFORMANCE DATA (above) agrees closely with test results. Early regenerator seals leaked too much and resulted in higher turbine inlet temperatures. This limited maximum output to 150 hp or 80% of design power. The latest seal design reduces this leakage well below the initial design goal.

effective inlet silencer further contributes to quiet operation of the Firebird II.

Quieting the turbines and compressor has unmasked another source of noise, however: the reduction gears. Ground, helical gears were used in an effort to avoid this problem, but it is obvious that other means must be employed. Divided loading and lower pitch line velocities make planetary gearing very attractive for this job.

A very distressing condition was discovered when the engine was first operated with an open exhaust system. The combustion system, which had been developed for low carbon formation, produced aldehydes that were more acrid than any diesel engine exhaust. This was apparently a combustion phenomenon like carbon or smoke formation but, unlike these, could not be visually detected. Spray pattern and liner design proved to be the means of attacking this problem. The odor is barely noticeable now and with further development can be completely eliminated.

Improved Performance

Performance of the GT-304 in the Firebird II shows significant improvement over the Firebird I installations. The engine noise level is greatly reduced and can be further improved with better reduction gearing. The fuel consumption has been reduced by at least 50%. The acceleration delay is notably less and low speed acceleration is enhanced by the four-speed transmission. Thus, it appears that the fundamental design objectives of the GT-304 engine—reduced fuel consumption and improved low speed performance—have been accomplished. Full evaluation of the engine must await more comprehensive test cell and proving ground work.

The Future of the Whirlfire

Development of the GT-304 engine will proceed along three general lines: thermodynamic improvements, increased durability of components, and a reduction in the amount of critical material required for fabrication.

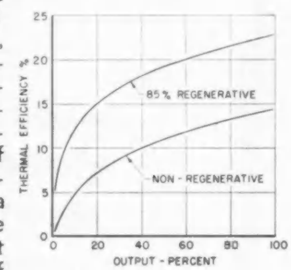
It certainly should be possible to improve both effectiveness and pressure loss of the regenerators. Many parts of the engine are fabricated from better materials than are actually required. This is partly due to lack of information and partly due to the fact that material cost is soon obscured in handmade prototypes. Test engines can now be instrumented and operating conditions determined to help in more logical materials selection. The goal of this program is an engine weighing less than 3 lb/hp having thermal efficiency approaching that of the reciprocating engine, and containing less than 10 lb of nickel or other critical materials. Our work to date does not show any reason to believe this cannot be accomplished.

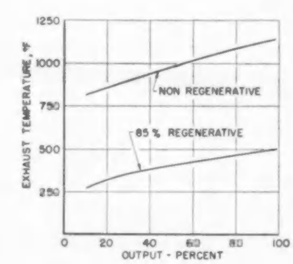
For complete paper (in multilith form) on which this abridgment is based, write SAE Special Publications Department. Price: 35¢ to members; 60¢ to nonmembers.

Why Regeneration?

IN automotive gas turbine engines *regeneration* refers to the process of using the hot turbine exhaust to help increase the heat of the incoming air. This increases the thermal efficiency of the cycle, reduces the exhaust gas temperature, reduces the pressure ratio to within range of a radial flow compressor, and reduces fuel consumption.

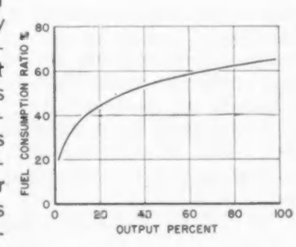
A typical regenerative cycle operating at 3.5/1 pressure ratio, with a 85% effective regenerator and 5% leakage, shows an efficiency margin of about 8 percentage points over a non-regenerative cycle operating at a pressure ratio of 4.5/1.





Exhaust temperature of the regenerative cycle is about 600 F lower than the non-regenerative cycle. At full load the regenerative engine exhaust is about 550 F and at idle it is only about 250 F.

At full load, the regenerative cycle uses only 65% of the fuel used by the non-regenerative engine. At 10% load, less than 40% is required. This is particularly advantageous for automobiles where the powerplant operates most of the time at part load.



Memo to:

The Young Graduate Entering Fuel Research—

—you will be disciplined by deadlines, challenged by competition, and judged by results. To get results, you must know how to attack the problem and what testing techniques to use.

APPLIED research aims to apply the discoveries of fundamental research to some specific use or to the solution of some immediate problem. Its supporters are businessmen who want results—and they want them before another company, industry, or country gets them. So, the young graduate enters a field where careful planning, the definition of objectives, and directed effort and scheduling are a must.

The young researcher seldom has time to collect all the scientific data that he would like to have help him in his project. He is disciplined by deadlines, challenged by competition, and rewarded by results. And, to be successful, he must first understand the nature of the result by which he will be judged.

Judged by Results

Fuel research is more often than not applied research and the result is usually a careful and inspired measurement of fuel performance in the powerplant. Here, the importance of selecting the right analytical and engineering techniques is paramount. It is, in fact, the keystone of the structure which allows the fuel research scientist to gear down the forces of nature to a speed which can be used by man.

The young researcher must decide how he will attack a given problem. Should he work on a process to make a given product better and cheaper, or should he work on changing the product and then see what process research is required. Extensive study of all phases of the problem is necessary before an intelligent decision can be made and actual experimental work begun.

Two Methods Contrasted

As an example, let's take a look at one of the problems in the development of a diesel engine. The problem here is to mix the fuel and air intimately in the combustion chamber of the engine to give complete and efficient combustion.

One group attacked this problem by designing an expensive and delicate fuel injection system to do the mixing. A research project was then carried out to produce this system cheaply and efficiently. With the aid of expensive production machinery,

resulting from this research, many very fine engines were produced at relatively low cost.

The alternative used by a second group was to work on the principle of moving the air into the fuel—thereby eliminating the need for perfect fuel injectors. This approach developed a combustion chamber and an air intake so that the air movements within the combustion chamber are used to mix the fuel and air prior to burning. Unless carefully done, this approach might have resulted in lower engine efficiency due to high pumping losses and some extra loss of heat through the cylinder walls but does result in an engine with more flexible manufacturing techniques.

Fuel research must sometimes be carried out with the object, not of improving or cheapening a product but, of maintaining existing quality. Therefore, successful product development largely depends on the techniques used in measuring its performance. If done poorly, not only is the product unsatisfactory, but much subsequent process research is wasted in trying to make the wrong product.

How to Measure Fuel Performance

If the measurement of fuel performance is so important in fuel development, how should we measure it? The first thing to decide is what one wants to find out. The second is how to find it out.

We place an engine on a test bed, couple it to a dynamometer and a fuel measuring device, and then start it up. The dynamometer and speed indicators indicate the power being produced and the fuel measuring devices tell us how much fuel is disappearing down the engine's gullet. That's easy. So are the fuel and oil temperature measurements. But, what we want to know is not the power the engine is giving but why it is not giving much more. We want to know how much of the fuel we see pouring down the engine's throat is being properly digested and how much is the result of pure greed. These are different problems, and their solution can be obtained only by painstaking and methodical detailed testing.

The art of testing consists really of keeping our patience and inventing new practical jokes to play upon the engine to get the results we want. However, in devising practical jokes to fool the engine, the research worker must be careful not to fall into traps which fool himself.

One trap into which researchers often fall is that of developing a laboratory research technique to aggravate or accentuate certain conditions to give quick results. This is understandable. The normal life of the product is often quite long, and the experimenter can't afford the time or money to study the problem under actual service conditions. So he introduces such conditions as higher temperature, higher pressure, and higher speed, to obtain results more quickly. But in doing so he may completely distort the picture.

For instance, certain fuels are known to affect exhaust valve life, and studies are required to correct this fault. The normal life of an exhaust valve should be about 1500 to 2000 hr, which involves 6 to 8 weeks of continuous operation day and night. By running an engine continuously at high loads and high speeds, conditions can be introduced which cause failure in about 150 hr, and this obviously is an attractive procedure. Unfortunately, raising valve temperature gives rise to a range of deposits having different melting points from those formed at lower temperatures, and these deposits have corrosive and other effects different from those which are normally experienced. The research worker, therefore, often draws false conclusions from such studies.

Another trap to guard against is the abuse of statistical techniques and the consequent accumulation of large masses of data. Properly used, the statistical method can yield very useful results and by its insistence on detailed planning of the work, often has the best effect in crystallizing the objectives before experiments are started.

Furthermore, do not forget the value of cooperative research. The research worker in the petroleum industry engaged in evaluating the performance of a given line of fuels or oils should not hesitate to get together with his opposite member in the automotive industry and work out methods of evaluation in cooperation with him in the field and in the laboratory.

Researcher Judged by Written Report

Finally, the research worker's supporters, business management, can only judge the value of the researcher's work if he produces an intelligent and readable report describing clearly the results of his tests. Five hundred hours of testing doesn't require a 500 page report full of mathematical formulas to justify the work. The results of the research will, however, be in effect zero unless others, particularly business management, can understand it. The written report is, therefore, the final and most important product on which the researcher is judged.

For complete paper (in multilith form) on which this abridgment is based, write SAE Special Publications. Price: 35¢ to members, 60¢ to nonmembers.

T. B. Rendel, Assistant to Vice-President, Manufacturing, Shell Oil Co.

Based on paper "Fuel Research" presented before the Yale University Student Branch of the SAE, New Haven, Dec. 7, 1955.

New Joint Committee Formed by

SAE Aeronautic and Ground

THE May 24 meeting of the SAE Technical Board gave final approval to the merging of the Society's aeronautical and automotive drafting interests into the SAE Joint Aeronautical-Automotive Drafting Standards Committee. The merger brings together two groups with a common aim—standardization of engineering drawing practice—into a unified group that can push further toward the goal.

The Committee hopes to contribute to the increasing movement toward standardization in basic engineering.

The most important advance in the field in the decade of 1940–1950 was the Unified Screw Thread. The success of this difficult undertaking has encouraged the gradual development of other basic standards, such as those on surface roughness, limits and fits, and drafting practice. Of these, one of the most important is drafting practice because drafting is the form of communication used by engineers to record their creative ideas and convey information to manufacturing which brings into reality the airplanes, automobiles, rockets, guided missiles, and the countless other products of inventive genius.

Company Drafting Standards

Almost all companies of any size have developed their own drafting manuals to suit their operations. Many have used the SAE Aeronautical and Automotive Drafting Manuals for guidance and reference material. In some cases, companies have completely adopted one of these two SAE manuals and supplemented it with additional pages covering special company practices. Where the SAE manuals have been used in either of these ways, they have tended to reduce greatly the needless variations which otherwise develop between the basic drafting practices of different companies.

The variation in individual company solutions to the same basic drafting problems is remarkable. To find two companies that have the same practices is certainly a rare experience. Each company has a different combination of conditions to meet, and its standards are developed by engineers of varying experience and background.

The extent of the support provided by individual company managements has a profound effect on the quality of company engineering standards—which vary from outstanding to worse than poor. One of the interesting phenomena is that the companies with reputations for the best products have the finest engineering standards since these are intimately tied into the high quality and low cost of the product. From these companies come the most important contributions in any effort to standardize on an industry, national, or international basis.

Industry Drafting Standards

In addition to individual company effort, there has been much industry activity sponsored by various technical societies and trade associations. To reduce the ever present variety in company standards to one good industry standard which represents the best practical solution, is a difficult but fascinating task. It requires considerable analysis, good common sense, and a willingness to cooperate and exchange ideas and experience. Of particular significance is the work of the SAE Aeronautical Drafting Committee S-1 and the SAE Automotive Drafting Committee.

The Aeronautical Drafting Committee S-1 was organized in 1940 with the purpose of establishing good drafting practices to be used in the design of aircraft engines, propellers, and accessories. The commercial airlines were later represented, and more recently the airframe manufacturers have also become very active. In addition the Committee has 10 consultants most of whom are heads of engineering drawing and graphics departments of leading universities in the United States. The work of this committee has been published in the Aeronautical Drafting Manual which has wide distribution in many industries and universities.

The Automotive Drafting Standards Committee was organized in 1946 to serve all phases of the ground vehicle industry, including cars, trucks, buses, farm tractors, constructional earthmoving equipment, and the parts and accessory suppliers to these industries. Need for these drafting standards resulted from the non-uniformity of drafting practice, not only between the various companies in the industry but also between divisions within the individual companies. These standards have been published in the Automotive Drafting Manual, which

P. G. Belitsos

Jet Engine Department, General Electric Co.
Chairman, SAE Committee S-1, Aeronautical Drafting Manual

Vehicle Drafting Groups

has had a very wide distribution.

In 1950 these two committees for the first time undertook the task of preparing a common standard on abbreviations of terms used on drawings. This worked out so well that in 1953 a Joint Subcommittee consisting of six men each from of the aeronautical and automotive Committees undertook the much more ambitious task of writing a common standard of the difficult subject of dimensioning and tolerancing. This standard was completed in 1954 and immediately became the most authoritative work of this subject to be published in this country. It represented the very best practices which had been tried and proven for many years by the mechanical producing industries of America.

Military Drafting Standards

Since the enactment of Public Law 436 (Defense Cataloging and Standardization Act) there has been a concerted action by all branches of the government to standardize military drafting practices. This work has been spearheaded by the Military Drafting Standards Committee which functions under the Office of Standardization. The primary purpose of these publications is to standardize the drafting practices used by all military activities. The implementation of this program should eliminate one of the major complaints of industry against the needless and costly requirement that several sets of drawings be made for the same article to satisfy the variations in basic engineering practices used by the different Services.

These Military Standards have also become mandatory in many cases on manufacturers who have contracts with the government. Since these Standards do not yet incorporate all of the best practices recognized in industry this has been the cause for considerable negotiation between trade associations, technical societies, and the government. Again this interplay of ideas between the military and industry has resulted in the stimulation of a creative flow of valuable information with resulting benefit to both groups.

To illustrate the interest in this activity, the following case is cited. In January 1954, a four-day meeting was called by the Air Force and the Navy Bureau of Aeronautics to review MIL-D-5028, which covers the preparation of manufacturer's engineering design drawings for aeronautical work. These services were exercising their right to make Military Standards mandatory in all their contracts with industry. Approximately 70 representatives from companies manufacturing airframes, guided missiles, electronic equipment, engines, helicopters, accessories, propellers, and ground support equipment participated in the meeting.

Subsequent to this meeting these companies through their trade association (the Aircraft Industries Association) formed a joint drafting panel that spent one year reviewing these Military Standards and making recommendations to improve them by including the latest and best practices used in industry. SAE was asked to assist in this gigantic coordinated effort by providing the technical assistance of its aeronautical drafting committee in analyzing the most important of these standards covering dimensioning and tolerancing (MIL-STD-8) and general drawing practice (JAN-STD-1). Industry recommendations are now being reviewed by the Defense Department and will gradually be incorporated into the Military Standards.

In order to present to the Military the best practices used in industry, SAE felt that active industry

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To develop a basic engineering standard acceptable to industry on a national scale is a colossal undertaking and one which entails the interplay of many creative forces, says P. G. Belitsos. Of these the following play significant roles:

1. **The voluntary contributions of many individuals who are the technical specialists on the subject;**
2. **The support of forward-looking top managements of progressive companies that are willing to contribute substantial financial backing as well as their accumulated technical skill and know-how;**
3. **The all important catalytic action produced by the competent staffs of technical societies and trade associations.**

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participation was required on the Military Drafting Standards Committee. It, therefore, spearheaded a move to have the Military accept industry representation. As a result of this, in October 1955, several industry groups were allowed to participate (SAE, American Standards Association, AIA, and Radio-Electronics-Television Manufacturers Association). The establishment of this new channel of communication will have far-reaching and beneficial effects on military and national drafting standards.

National Drafting Standards

In the last five years the ASA has been very active in the preparation of an American Drafting Standard Manual. When completed, this manual will describe the best practices used in the United States and will be used as a basis for negotiation in any unification program with the British and Canadians. It is expected that the latest practices established by the SAE efforts will be one of the important factors in establishing these American Standards.

Of considerable interest are similar efforts in Britain and Canada to establish national drafting standards. In 1953, the British Standards Institution published BS308, "Engineering Drawing Practice." This was the result of many years of research and study based on the brilliant work started by C. A. Gladman in his publications "Drawing Office Practice in Relation to Interchangeable Components," and the subsequent "Dimensional Analysis of Engineering Design," which is probably the most important work ever written on this subject.

The new concepts introduced in these documents in the area of geometric and positional tolerancing aroused considerable interest in the United States, and was one of the motivating forces in starting the joint SAE aeronautical and automotive work on this subject.

The Canadians were also working in parallel with the British and published their Mechanical Engineering Drawing Standards B78-1 in 1954. With the issuance of these standards, Britain and Canada have completed the ground work for negotiating an ABC international standard in which the three English-speaking countries could agree on a unified standard similar to the one developed on screw threads. These two standards introduced some new concepts in dimensioning and tolerancing which required extensive educational programs in their countries. These new practices are being tried and tested by the Services and various industries in England and Canada and considerable experience of value is being recorded for use in forthcoming ABC meetings.

Joint SAE Aeronautical-Automotive Drawing Standards

All of the activity covered above has set into motion the best creative thinking in this field. The fact that SAE, ASA, AIA, the military, and others are bringing to bear their best talents on this activity will result in an outstanding national standard which is truly representative of American practice. It is obvious that only the soundest practices will stand up under the scrutiny of all these groups.

SAE will play an increasingly important part now that its two strong drafting committees have combined to produce a common drafting manual. If two important segments such as the automotive and aeronautical can agree on one set of drafting standards, this will become a milestone in this national standardization effort.

A look at some of the projects and the broad plans reveals the importance of this activity and the far-reaching effect it will have on drafting practices:

Geometric and Positional Tolerancing—This is the keystone of the drafting standardization effort since it affects interchangeability, which is the basis of mass production. Many refinements of tolerancing have become necessary with the ever increasing requirements of new products and because of the need to eliminate recurring problems in engineering, manufacturing, and inspection. The principles developed in this area will help to eliminate many problems in mass production which originate on the drawing board. A standard on this difficult subject has already been issued by the SAE Joint Subcommittee. An improved version is now in process.

Simplified Drafting Practices—In the last few years there has been much lively debate concerning the merits of short cuts in drafting. The extremists on both sides have been very forceful and energetic in presenting their views. The SAE Joint Subcommittee has been writing a comprehensive standard on this subject under the title of "Conventional Representation." This will be the first standard to record those sound simplified practices that are widely used in industry. When given official sanction, this standard will help in reducing drafting costs in all drafting offices that use it.

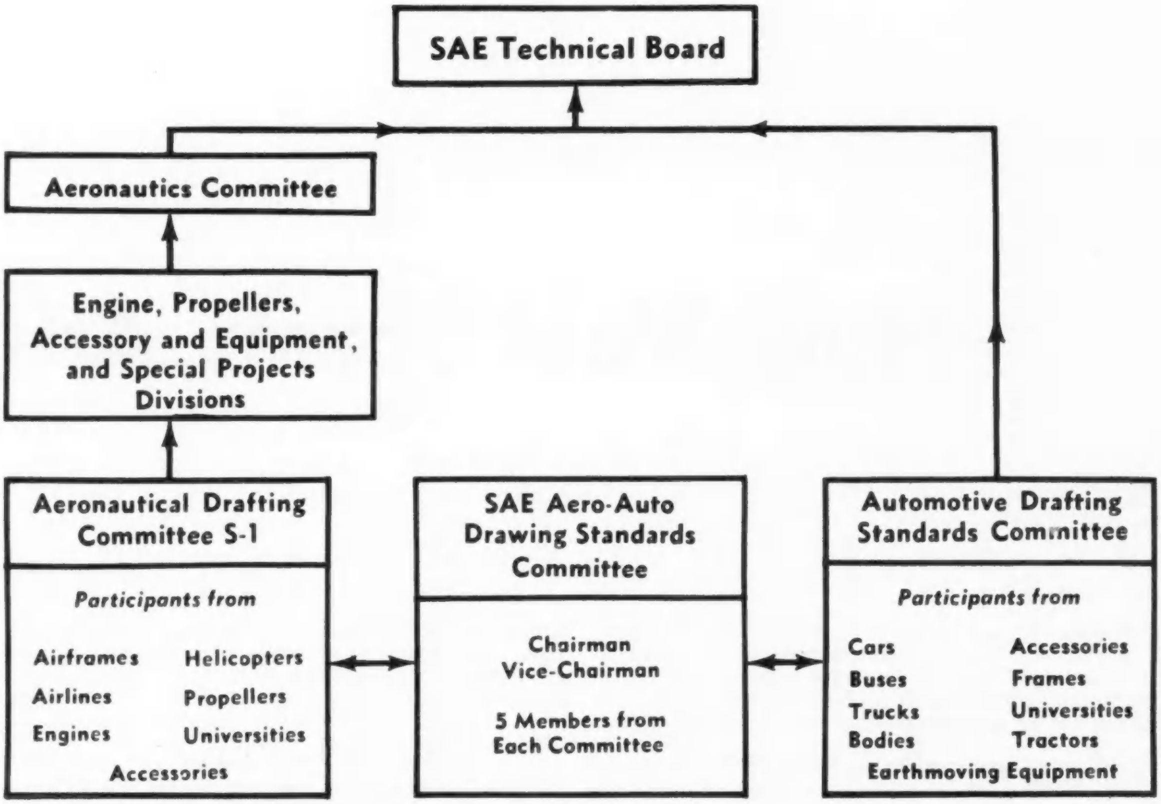
Dimensioning—Standards on the methods of dimensioning different features and characteristics of components will be established. An improved version of the existing publication on the subject will be prepared for the first issue of the joint manual.

Processing Information—A significant trend in modern drafting practice used particularly by companies that have large subcontract operation, is to record only the end engineering requirements on engineering drawings. The purpose is to allow maximum flexibility in the use of methods and equipment during processing. For example, several companies have eliminated the use of the terms drill, ream, bore, and punch. To what extent this trend will be recognized by this committee will be of considerable interest to industry.

Complete System of Decimal Dimensioning—The SAE Joint Committee will encourage the use of the complete system of decimal dimensioning in the mass producing industries. This should have some interesting results over the next decade, such as the following:

1. Universities will teach decimal dimensioning instead of fractional;
2. Text books will reflect this trend, and eventually decimal dimensioning will be taught in the grade schools;
3. The next generation of engineers and designers may think in terms of decimals only;
4. The sizes of such items as commercial tools, radius gages, and commercial cutters will eventually succumb to the trend and will be designated entirely in decimals.

Screw Threads—The method of specifying screw



The SAE Aeronautical and Automotive Drafting Committees will continue to operate as at present. Six representatives of each of these two committees will be elected to serve on the Joint Committee. They will be a policy-making group that will steer the work of the two working committees so that a single common SAE Manual on drafting practices can be published. The first issue of the joint Manual is planned for 1957. Standards which are common to both industries will be developed jointly by the two working committees. Each committee will also be free to develop standards which are of particular interest only to its industry.

threads will be standardized. Particular emphasis will be placed on threads which are special, modified, coated, or plated, and those having special lengths of engagement.

Free State Variation—The increased size of such products as aircraft jet engines and guided missiles with the emphasis on high speed and reduced weight presents problems in the dimensional control of the shape of sheet metal components. Although large thin shapes can be maintained accurately in the machining fixtures, they become distorted when they are removed from the restraints used in the fixtures. This distortion may result because of the weight or flexibility of the part, or because of internal stresses released by the manufacturing processes. Thus in the free, unrestrained state the configuration of this type of component is other than that which it takes when properly assembled with other parts and consequently is also different from the one delineated on the drawing. This presents many problems in the inspection and acceptance of these parts. A standard method to specify the control of these free state variations on engineering drawings will be developed so that components can be assembled and will function properly.

Reduced Size Drawings—Developments in photography and reproduction techniques are affecting the preparation of drawings. No longer will the engineer or other users of drawings be required to pore over prints that are 10 to 20 ft in length and hike from one end of the drawing to the other obtaining information. Drawings are being successfully reduced in size by 50%. In order to maintain legibility at reduced size, new techniques will be standardized for use in the preparation of drawings affecting the size of letters, spacing, sectioning, thickness of lines, dimension lines, and placement of dimensions.

This joint effort is a landmark in SAE history. It represents a voluntary effort on the part of the aeronautical and automotive forces in the Society to combine in order to further the contributions of the Society to technical development and standardization. If this merger fulfills the dreams of its sponsors it should wield a truly significant influence over national and international basic engineering standards.

How Steel Seams Are

FOR detecting and measuring seams in steel there are several widely used methods—each particularly suitable for specific applications. In determining which method to use for a job the following technical factors should be considered:

1. Kind of material to be tested (steel composition)
2. Thickness (can vary from 0.05 to 6 in.)
3. Geometry (whether rod, wire, bar, shaped, etc.)
4. How processed (whether drawn, cold-rolled, hot-rolled, etc.)
5. What is to be evaluated (whether detection or measurement)
6. Minimum depth of seam to be measured.
7. Surface condition (can vary from smooth to rough-scaled, hot-rolled finish)
8. Accuracy required

The relative merits of five methods for measuring as well as detecting seams in steel raw stock—in accordance with the above considerations—are as follows:

Method	Technical Applicability	Reliability	Speed of Testing
Penetrating radiation	poor	good	poor to good
Penetrant	good	poor	poor
Ultrasonic	poor to fair	fair	fair
Magnetic particle	poor	fair	fair
Magnetic or eddy current	fair to good	good	good

It appears that magnetic or eddy current techniques are best for detecting and measuring seam depth. However, each specific testing job should be evaluated in itself before deciding upon a nondestructive test method.

Magnetic Seam Detection

The magnetic seam detection technique is fast, inexpensive, and applicable to parts that are cylindrical, nearly symmetrical, and which contain typical radial or longitudinal cracks, breaks, or inclusions.

Fig. 1 is a functional diagram of a magnetic seam detector. A permanent magnet is passed closely over the surface of the steel ring magnetizing it slightly. At a crack or irregularity in the surface this residual magnetism forms a bulging or fringing field which extends beyond the surface. A pickup coil, similar to those used in tape recording machines follows 180 deg behind. As it passes closely over a bulging field, a signal is induced showing the presence of the crack or irregularity. This particular detector was built with an adjustable radius feature to permit the testing of rings of various sizes. The ring is placed on the platform in position against a guide and the crack indication is shown on a cathode ray oscilloscope in front of the operator.

Another machine operating on the magnetic detection principle is shown in Fig. 2. It tests for laps in the metal which occur when the raw stock is formed into a rod. As the rods pass through the brass tube and through the rotating permanent magnet they are magnetized. Flaws cause bulging fields which are picked up by the pickup head as it rotates around the rod farther along the fiber tube. The oscilloscope indication is the same as shown in Fig. 1.

Other machines are available in which the part rotates past the stationary pickup head. Cracks in a roller from a roller bearing have been detected between 0.0005 and 0.0002 in. width.

Detected and Measured

By increasing the speed of rotation, the magnetizing force can be increased and the signal made larger thereby increasing sensitivity. However, in the machine just described, higher speeds would also increase vibration of the rods in the tube and vary the distance between the rotating head and the material being tested, thereby affecting results.

The principle advantage of this method is its speed. An untrained operator can inspect rollers by this method at a rate of one every 3 sec.

Eddy Current Seam Detector

Another method of detecting seams in steel depends upon generating eddy currents in the surface of the piece being inspected. If a seam is present the eddy currents must detour around the bottom

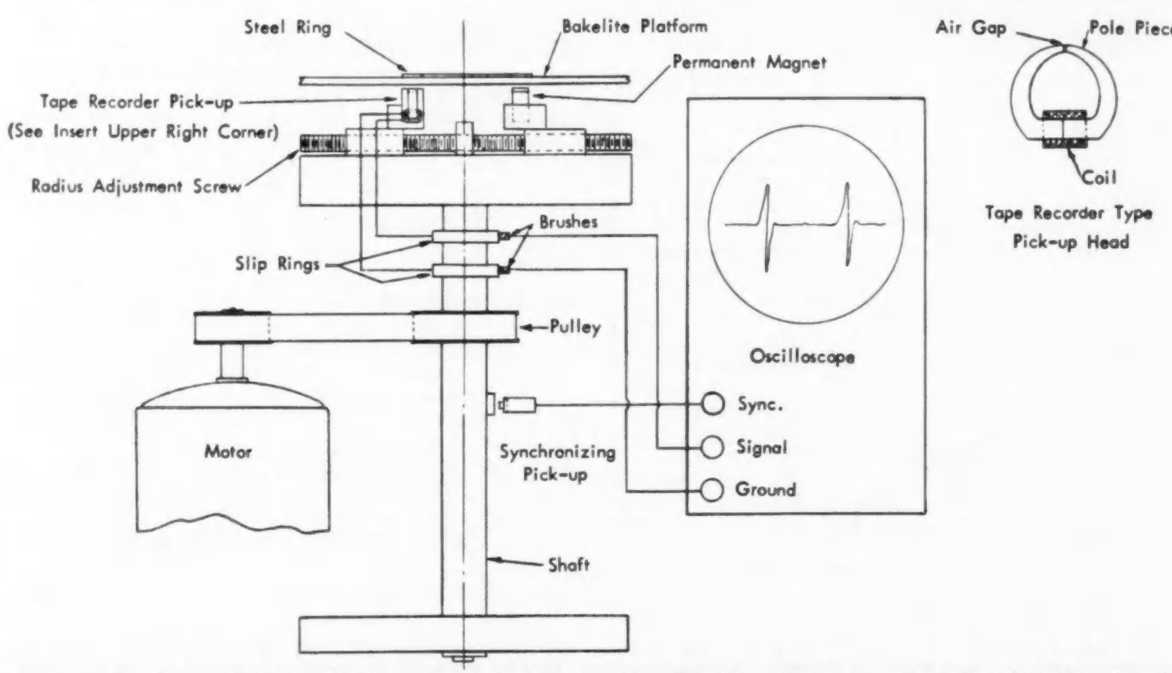


Fig. 1—A magnetic seam detector for locating seams and cracks in steel rings. The pickup and magnet are rotating beneath the ring. A crack in the surface forms a bulge in the residual magnetic field which can be detected by the pickup coil.

This article is based on papers presented at the symposium Methods of Detecting and Measuring Seams **sponsored by Division XXXA of the SAE Iron and Steel Technical Committee in Detroit, Jan. 11, 1956. Participants in the symposium were:**

J. R. Gustafson, Ford Motor Co.

Hamilton Migel, Magnaflux Corp.

C. H. Hastings, Watertown Arsenal Laboratories

J. C. Smack, Sperry Products, Inc.

W. A. Black, Republic Steel Corp.

E. F. Weller, General Motors Corp.

F. W. Chapman, General Motors Corp.

J. M. Callan, Magnetic Analysis Corp.

A. K. Saltis, Magnaflux Corp.

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of the seam, thereby lengthening the current path and reducing the magnitude of the induced current. The increase in length and the change in current value are both proportional to the depth of the seam. A pickup circuit provides a meter reading calibrated in terms of seam depth.

Fig. 3 is a photograph of this type detector which was developed in the Electrical Laboratory of Republic Steel Corp. about eight years ago. The search coil is mounted in a handle with an indicator light. In its initial version the instrument was used merely as a "go and no-go" device. As the detector head moves over the seam the indicator light in the handle flashes whenever the seam is deeper than 0.030 in. Relative movement between the detector coil and the piece is required for the operation of this instrument.

Later developments produced a direct-reading instrument, with a meter calibrated in terms of seam depth.

It can also be incorporated into a production line. Pipe couplings cut from a seamless tube are fed into a cleaning station and from there into an inspection station. At that point the seam depth indicator operates as a "go and no-go" gage, allowing couplings to go into one receptable if they are satisfactory and deflecting them by means of an automatic elevator into another receptacle if they are no good. Two of these automatic inspection ma-

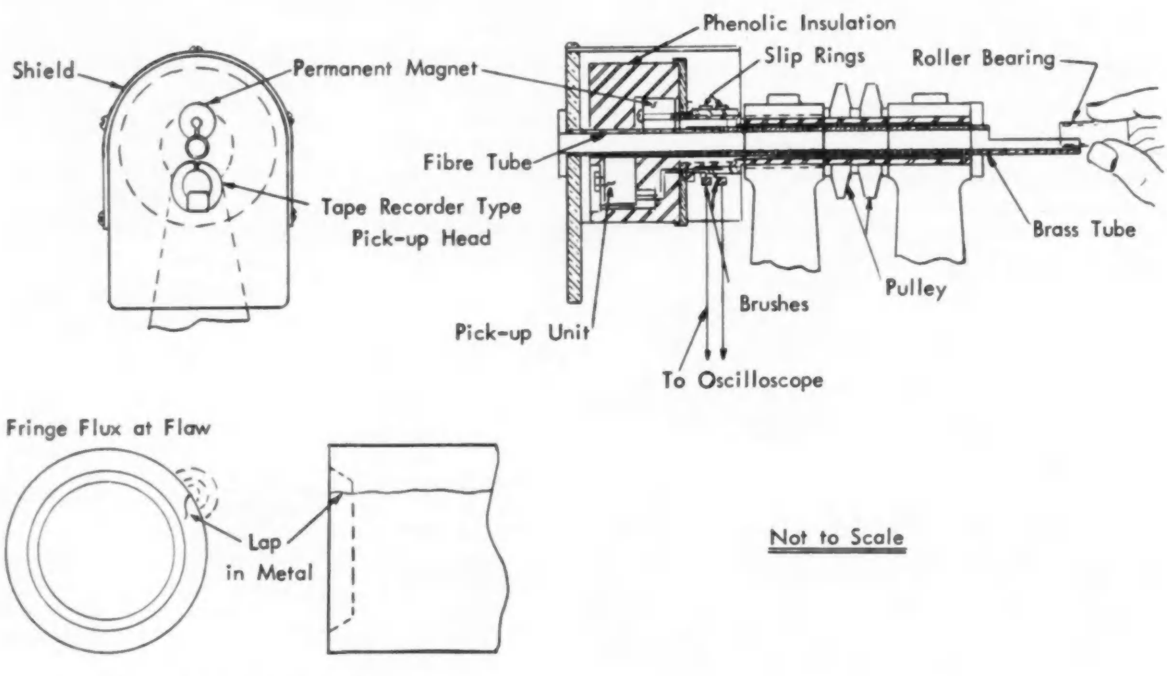


Fig. 2—Plungers are examined for cracks by this magnetic seam detector. The pickup and magnet are rotated around the part. The plunger is inserted on the right. It first passes the magnet and becomes magnetized. Then the pickup coil detects the bulging magnetic field and transmits the signal to an oscilloscope.

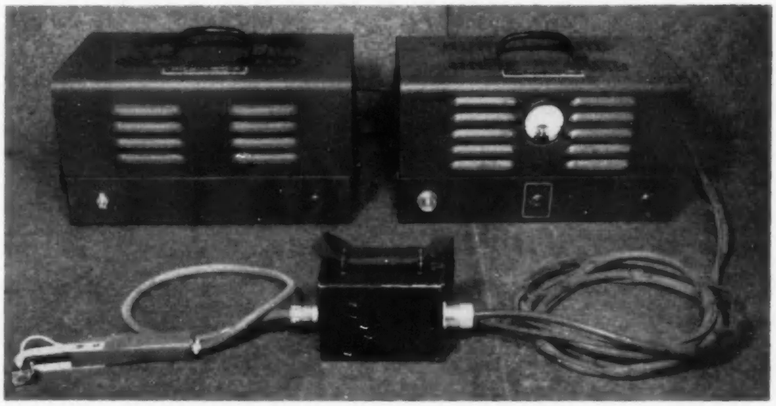


Fig. 3—Seam depth indicator developed by Republic Steel Corp. has been in use eight years detecting flaws which come to the surface of the material.

chines have been in use at the Republic Steel plant in Chicago for about two years.

The seam depth indicator can detect only those defects which come to the surface of the material. If a film of metal, no matter how thin, bridges the gap at the surface, the seam depth will not be measured.

Since the magnitude of the eddy currents depends upon the resistance of the material being inspected, differences in resistance will affect the accuracy of the instrument. If the difference in resistance is large, such as between steel and copper, the values of circuit components must be changed to make the instrument useable.

It is limited to use below 140 F, since higher temperatures damage the search coil mounting. Oil and water damage the probe unless it is provided with special protection.

Surface oxide does not interfere with the use of the seam depth indicator if the oxide is tightly adherent. Loose oxide must be removed.

If the surface under inspection is curved, the probe must be positioned carefully. Diameters less than 3 in. require a special probe.

While the instrument can be used to measure seam depths from 0.015 to 0.12 in. the range can be extended under certain limited circumstances. Accuracy will generally be within 10%; however, like all nondestructive tests, it is subject to human errors and unpredictable conditions.

Neither eddy current nor magnetic analysis methods can detect flaws close to the ends of bars and tubes. Also, they have difficulty detecting a seam if it is perfectly uniform and continuous.

Normally the magnetic analysis method can detect noncontinuous seams which are at least 1.5% the diameter of the bar or tube. While sufficient data is not available yet, it is expected that eddy current techniques have equal sensitivity.

Magnetic Particle Inspection

One of the oldest and still one of the most reliable nondestructive methods for the detection and measurement of seams in bar stock is the magnetic particle technique. It is quite sensitive and is presently used in the steel industry to test seamless tubes, welded tubes, ground bars, cold finished bars, hot rolled bars and billets. (See Fig. 4.)

The piece to be inspected is magnetized so that

Fig. 4—Magnaglo inspection is used in a steel mill for 100% inspection of billets up to 8 in. diameter and 12 ft long.

north-south poles are produced on opposite edges of a discontinuity. Magnetic particles are introduced into the leakage field between the poles and held there by magnetic flux. The readily visible accumulation of the particles indicates the discontinuity. Usually the fine magnetic particles are suspended in an oil or water bath.

Only crack-like flaws are detected by magnetic particle inspection. Gouges and scratches cannot generally be indicated. It cannot detect cold worked areas, residually stressed areas, and metallurgical changes, either.

Leakage field strength is determined by the level of magnetism and the size of the seam in the bar. Therefore, if the level of magnetism is kept constant, the larger the seam the larger the leakage field will be.

To help evaluate the amount of magnetic particles that are caught by the seam flux, the particles are made fluorescent. Then, under black light, the cracks show up brightly. (See Fig. 5.)

At present the fluorescent magnetic particle method requires a trained inspector to evaluate results. However, soon the size of the crack may be measured by electronic equipment which will scan

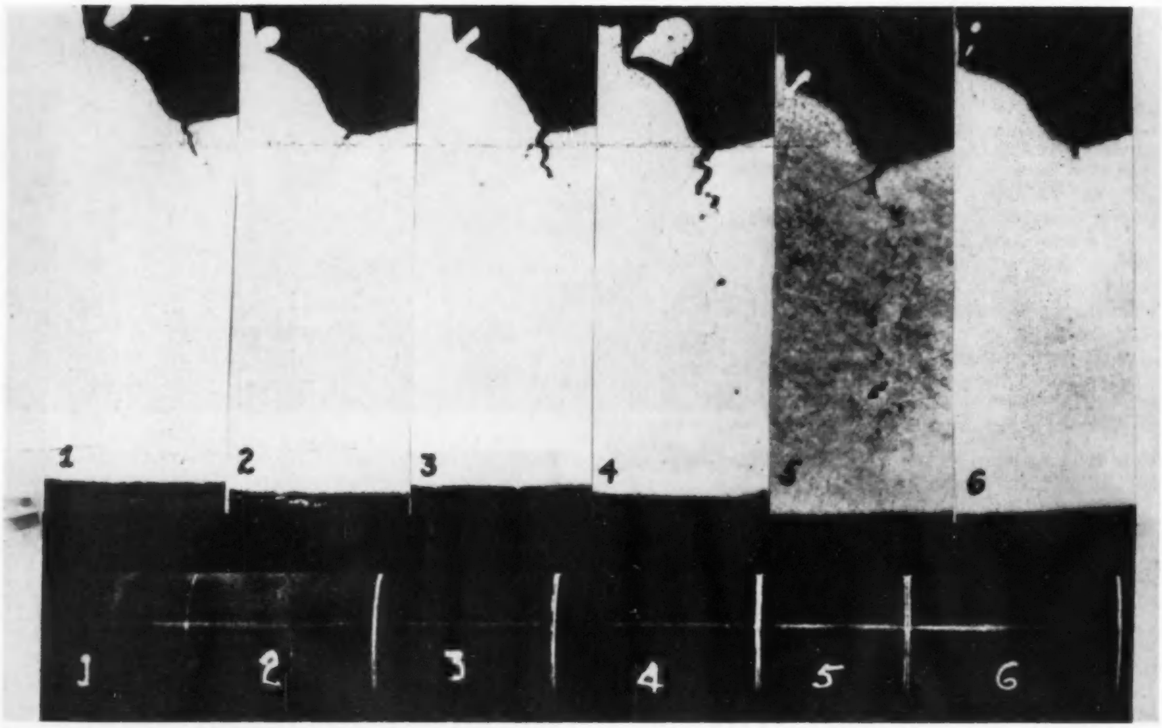


Fig. 5—(Above) Photomicrograph of sections taken through steel tubing wall at various points. (Below) Black light photograph of Magnaglo indication of a crack in the tubing. Intensity of the fluorescent magnetic particles varies with the depth of the crack.

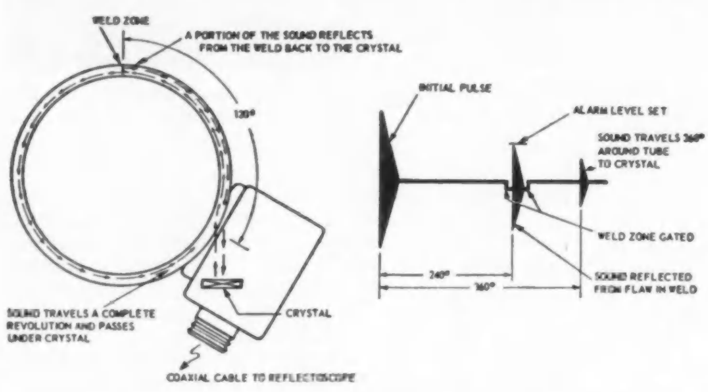


Fig. 6—Ultrasonic search unit sends waves around circumference of the pipe. At a discontinuity some of the sound reflects back to the crystal. A pip appears on the oscilloscope with amplitude proportional to the reflected energy and the area of the defect.

the fluorescent particle groupings and translate them directly into depth measurements.

Ultrasonic Detection of Seams

Ultrasonic inspection, after 11 years of practical development, is used extensively in the metals industries for nondestructive inspection of ingots, blooms, billets, bars, plate, forgings, extrusions, pipe, and other drawn and welded fabrications. It can locate inclusions, segregations, porosity, pipe, cracks, bursts, flaking, and seams.

In homogeneous metals having elastic properties, ultrasonic vibrations will travel 100 ft or more, will be confined to a beam, and will be reflected from boundaries of discontinuities as well as the outer surfaces of a piece of metal. When the vibrations pass between materials having different elastic properties, certain conditions will change the mode of vibrations. This is particularly important for detection of surface seams.

A pulsed beam of vibrations is sent into a piece of metal. It is reflected from either internal or surface discontinuities and the reflected pulse is viewed on a cathode ray tube screen. The exact location of the discontinuity may be determined from the position

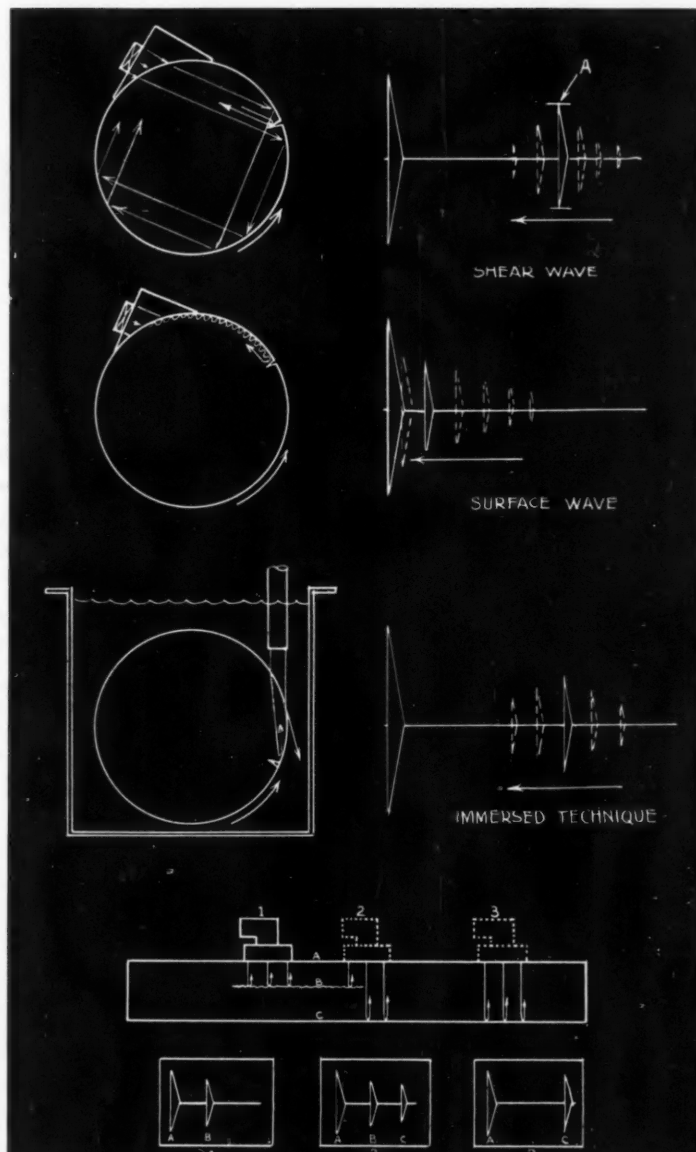
of the reflected pulse indication on the horizontal sweep line as shown in Fig. 6.

If an angle-type search unit is placed on the surface of a round bar, it is possible to scan the entire surface by moving the search unit around the bar or rotating the bar. If the defect is large enough it will reflect the entire beam. A smaller defect will only reflect part of the beam.

The search beam can be used normal to the surface for testing heavy plate for laminations and other internal defects as well as surface seams. Or round billets and bar stock can be tested by several different methods as shown in Fig. 7.

Tubing and pipe from fractions of an inch in diameter to many feet in diameter may be ultrasonically inspected. Completely automatic equipment can inspect tubing, pipe, and bar stock at rates of 60 to 120 fpm.

Fig. 7—Ultrasonic Testing Techniques



Proper selection of an angle search unit will project the beam into bar stock so that surface defects are located by rotating the piece and moving the search unit along the bar. "A" represents a pip on the oscilloscope caused by reflection from crack.

Surface waves can be generated around the rotating bar to locate surface and sub-surface defects. The pip increases in height as the defect comes closer to the search unit. Testing depth below the surface varies in steel from 0.250 at 1 megacycle to 0.50 at 5 megacycles.

In immersed testing the water acts as a variable couplant or wedge in place of the plastic contact search unit. Inspection may be made through the center of the piece or at any angle to cover the entire bar. (See SAE Journal, Dec. 1954, p. 30 for complete description.)

Laminations and internal defects can be detected by using the beam normal to the surface. (1) Entire pulse is reflected by the lamination. (2) Part of beam is reflected while balance goes on to be reflected by the other side. (3) Plate with no defects would show only reflection from the other side.

ROTOR TYPES Piasecki YH-16 (left), as is typical of helicopters, is an efficient producer of vertical lift because of large rotors. But rotor is inefficient in forward flight. Unloaded rotor of McDonnell XV-1 (center) and tilting rotor of Bell XV-3 convertiplane (right) are attempts to improve forward flight qualities without losing lifting advantage.

Variety of VTOL Aircraft

THIS article is based on the papers:

"An Appraisal of VTOL Aircraft"

by K. S. Coward and E. R. Hinz, Ryan Aeronautical Co.

"Convertiplanes and Other VTOL Aircraft"

by R. J. Woods, Bell Aircraft Corp.

"Some General Considerations Concerning VTOL Aircraft"

by Charles H. Zimmerman, NACA Langley Aeronautical Laboratory

The papers were presented at the SAE National Aeronautic meeting held in New York, April 11, 1956. Complete papers are available in multilith form from SAE Special Publications Department at 35¢ each paper to members, 60¢ each paper to nonmembers.

AVIATION has reached the stage where it has both the means and the need for aircraft capable of vertical take-off and landing, VTOL for short.

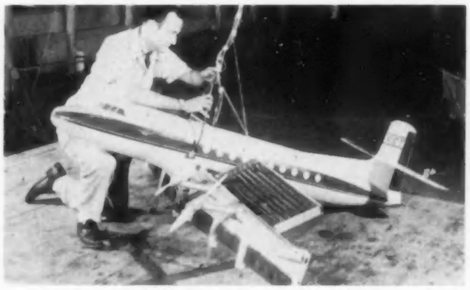
The helicopter is actually a type of VTOL aircraft already in general use. The convertiplane—which in its most common form is a prop-wing plane which takes off as a helicopter, converts to conventional propeller-driven fixed-wing operation for translational flight, and re-converts to helicopter action for landing—is another type of VTOL craft. Other varieties of VTOL craft divert jet thrust downward for take-off and landing, or rotate the propulsion package, or—as in the case of tail-sitters—rotate the entire aircraft.

Greatest boon to VTOL design is the gas turbine engine. This engine, with its light weight and high power output, is figuratively allowing us to "fly the barn door." Although its fuel consumption is notably higher than the reciprocating engine, its much smaller size and greater flexibility facilitate its use in new and less conventional designs.

Following closely behind powerplant development as a necessary adjunct to VTOL airplane development are the advances being made in the knowledge of the aerodynamics of flight. Such advances now assure us that the VTOL airplane can hover the same as a helicopter, fly in conventional flight the same as airplanes have for the past 50 years, and also fly the transition region between these two extremes.

Materials and structural design are a third stepping stone to the development of the coming VTOL airplane. High strength aluminum, stainless steel,





PROPELLER TYPES Some designs use propeller for vertical lift and wing in forward flight. Convair tail-sitter (left) is example. Hovering control is effected by use of slipstream and tail plus pendulum function. NACA has flown models having tiltable wings (center) and wing rear sections which deflect to form vanes, slots, and flaps to divert slipstream downward (right).

Types Now Feasible

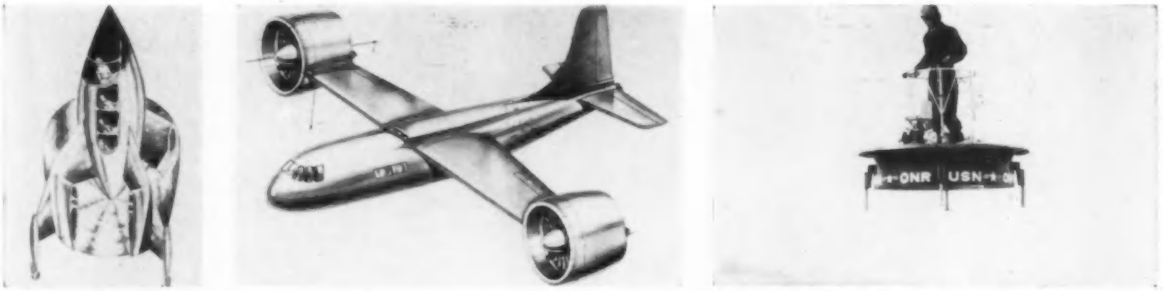
and titanium are yielding improved strength-to-weight ratios. Fibrous glass, honeycomb, and foamed-in-place plastic are permitting fabrication of needed light-weight, complex shapes. Huge mechanical milling machines for taper milling, large presses for high strength forgings, and chemical milling for sculpturing of metal are all assisting in the drive towards the needed efficient, light-weight structures.

The present state of the art has reached a level whereby we can proceed with the detail design of VTOL airplanes. Background research work into different types of these aircraft has already been done by the National Advisory Committee for Aeronautics and other government and academic institutions. They have shown, through wind tunnel tests and flying scale models, that many aircraft other than helicopters can take off vertically, make a transition into conventional forward flight, and return to a hovering attitude. There have also been several piloted research aircraft which have very recently been flown to prove the same capabilities. With so many different concepts apparently available we would do well to appraise the VTOL principles and single out those proposed designs which show a significant future.

Fundamentals of Direct Lift

Analysis of the fundamentals of direct lift brings out the following concepts:

- Power required for hovering varies from zero for a balloon to a very large value for a rocket-supported vehicle.
- Upward thrust necessary to support a heavier-than-air vehicle equals the product of the mass of air accelerated downward per unit time times the velocity (assuming a uniform jet velocity) imparted to it.
- Power required per pound of thrust varies linearly with the velocity imparted to the mass of air accelerated downward. The necessary power (that is, the kinetic energy per unit time) equals one half the product of the mass of air per unit time multiplied by the square of the velocity imparted to it.
- A low-velocity jet, such as that produced by a helicopter rotor or an airplane propeller, is most economical of fuel for an aircraft performing a mission requiring much hovering. The high-velocity jet of a turbojet engine entails very high fuel consumption.
- Jet velocity is proportional to the jet diameter for a given thrust and a given density of the air in the jet. Therefore, jet diameter or disc loading is an indication of the power required per pound of weight, or of the fuel consumption per pound of weight per hour for a hovering aircraft.
- Diameter of an unshrouded, single-rotation propeller must be of the order of 1.6 times that of the exit area of a propeller shroud in order to support a given weight with the same horsepower.
- Power required for hovering and slow speed flight increases rapidly with increase in weight. (In hovering, power required increases as the three-



DUCTED PROPELLER TYPES Duct around propeller improves thrust efficiency but adds to stability and control problems. Configuration has been proposed for tail-sitters like Coleopter (left) as well as for convertiplane transport design studied by Bell (center) and Hiller flying platform (right). This one-man helicopter has two co-axial three-blade rotors 5 ft in diameter.

Fundamental Equations for

Assuming a uniform velocity in the thrusting jet, the mass of air per unit time is

$$m_j = \rho_j A_j V_j$$

The thrust is

$$\begin{aligned} T &= m_j V_j \\ &= \rho_j A_j V_j^2 \\ &= 2q_j A_j \end{aligned} \qquad (1)$$

The kinetic energy in the useful portion of the velocity in the jet, that is, that part of the jet velocity parallel to the jet axis, is

$$KE_j = \frac{1}{2} m_j V_j^2$$

The brake horsepower to produce the jet is

$$\begin{aligned} HP &= \frac{KE_j}{\eta_1 550} \\ &= \frac{m_j V_j^2}{1100\eta_1} \end{aligned}$$

The horsepower per pound of thrust is then

$$\frac{HP}{T} = \frac{V_j}{1100\eta_1}$$

The fuel consumed per hour per pound of thrust is

$$\frac{W_F/\text{hr}}{T} = \frac{HP \times \text{sfc}}{T}$$

If the heat content of the fuel is assumed to be 20,000 Btu per lb,

$$\text{sfc} = \frac{33{,}000 \times 60}{20{,}000 \times 778\eta_2}$$

Therefore

$$\begin{aligned} \frac{W_F/\text{hr}}{T} &= \frac{V_j}{1100\eta_1} \times \frac{33{,}000 \times 60}{20{,}000 \times 778\eta_2} \\ &= \frac{0.000116V_j}{\eta} \end{aligned}$$

The power required per pound of thrust can also be expressed in terms of the air density in the jet and the jet area loading

$$\frac{HP}{T} = \frac{V_j}{1100\eta_1}$$

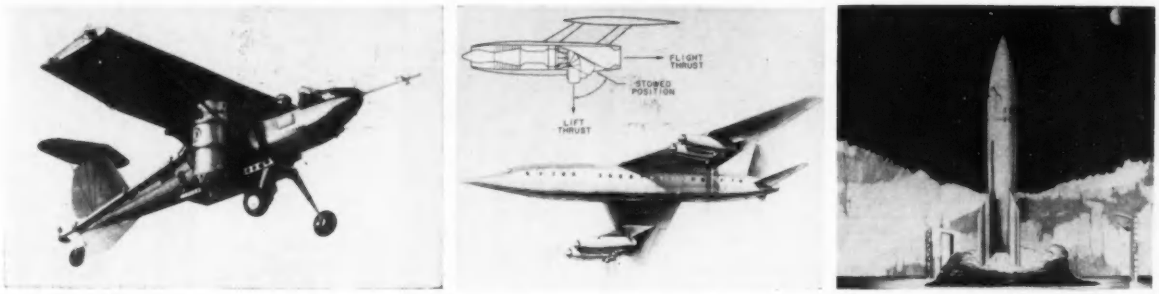
or

$$\frac{HP}{T} = \frac{\sqrt{T/A_j}}{1100\eta_1 \sqrt{\rho_j}} \text{ from (1)}$$

In the case of a propeller or rotor the jet area is, by the momentum theory, one half the disc area. Making this substitution,

$$\frac{HP}{T} = \frac{\sqrt{2T/A_r}}{1100\eta_3 \sqrt{\rho_j}} \qquad (2)$$

[Equation (2) does not hold for shrouded propellers. For a shrouded propeller, it can be shown that $A_r = 25A_j$ (assuming $\eta_3 = 0.85$ and $\eta_1 = 0.95$), and the power required per pound of thrust changes accordingly.]



JET TYPES Since jets have no prop slipstream in which to operate aerodynamic controls, other means of low-speed control are required. Bell test bed (left) used two Fairchild J-44 jets for direct lift and propulsion, Continental Palouste turbine air compressor for jet reaction control system. Bell has also studied supersonic jet convertiplane transport (center). Tail-sitter (right) rocket plane is another possibility.

VTOL Flight

Symbols

m_j mass of air per unit time, slugs per sec

ρ_j density of the air in the jet, slugs per cu ft

A_j cross-sectional area of the jet, sq ft

V_j air velocity in the jet, fps

T thrust, lb

q_j dynamic pressure in the jet, lb per sq ft

η_1 efficiency of conversion of brake horsepower to useful jet kinetic energy

W_F fuel weight, lb

sfc specific fuel consumption, lb fuel per hp-hr

η_2 overall thermal-mechanical efficiency of the powerplant

η overall efficiency of conversion of heat content of fuel into useful jet velocity

A_r rotor (or propeller) disc area, sq ft

η_3 efficiency of conversion of horsepower applied to the rotor into kinetic energy in the jet

halves power of weight.) And, conversely, power required for hovering decreases rapidly with decrease in weight, making weight reduction especially worth while in VTOL aircraft.

• The center of gravity of a VTOL aircraft must be above the center of the jet for balance in hovering flight. Therefore, provision must be made for effectively translating or inclining the axis of the jet relative to the aircraft to permit balance over the range of center-of-gravity positions possible with various conditions of loading. This can be done by translating the jet thrust unit, or by rotating it if it is sufficiently far above or below the center of gravity. It can be done also by changing the direction of the jet by airfoil surfaces used as deflection vanes or by differential thrust control on two or more thrust units or by variation of the thrust of auxiliary thrust control units.

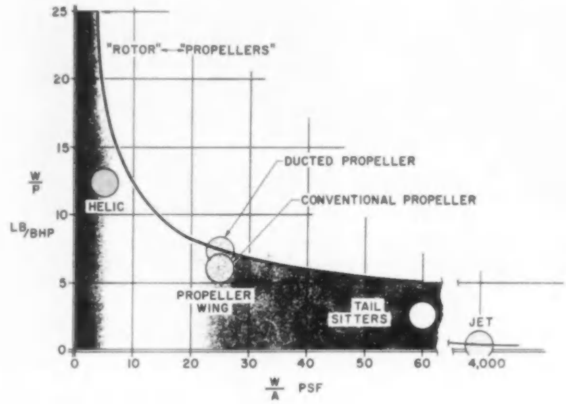
• The fundamental stability and control requirement for a vertical flight aircraft is that it shall not be so unstable as to be difficult to fly by a normally skillful pilot with the controls provided. No current configuration is completely stable in hovering flight without use of artificial stabilizing devices. However, complete stability is not necessary. The penalties paid for instability are additional pilot training and inability to fly satisfactorily under blind flying conditions.

Need for VTOL

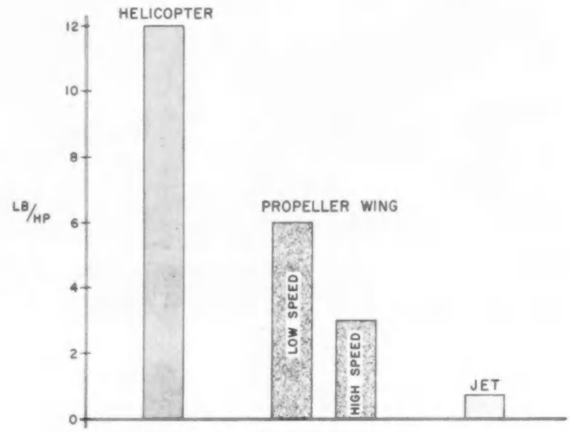
We are being led into the field of VTOL aircraft by three very persuasive influences: (1) airfield restrictions, (2) aircraft design limitations, and (3) a need for expanding the freedom of both civil and military air operations.

The increase in cruising speeds of aircraft has generally been accomplished at the sacrifice of low-speed flying capabilities. Runway lengths have been allowed to increase at a slow but consistent rate until we are now speaking of runway requirements in the 10,000-ft class. These may be satisfactory for transcontinental or intercontinental air operations, but they are an extreme burden for short haul or military combat operations.

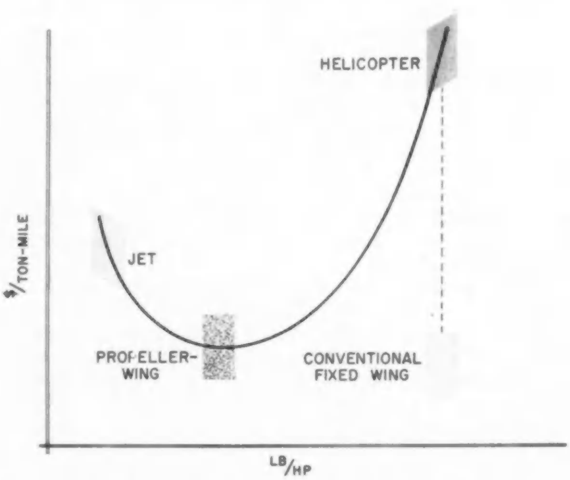
If we could content ourselves to operate from the plains and deserts of the world, the increased runway length would be of little concern, but economic



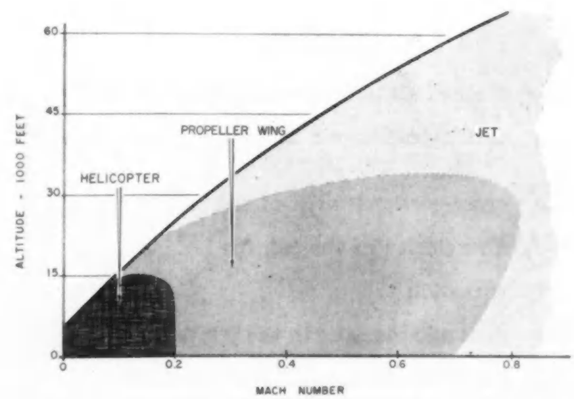
BETWEEN POWER LOADING and disc loading of any heavier-than-air VTOL aircraft, there exists a basic relationship. Curve shown indicates upper boundary above which it is impossible to hover. (Static efficiency is 100%.) Prop-wing types occupy broad central band.



IN PURE LIFTING ABILITY, large articulated rotor of helicopter leads. Among prop-driven VTOL types, big low-speed, low-disc loading craft have most lifting ability. Jet VTOL aircraft for very high speed forward flight have least lifting ability.



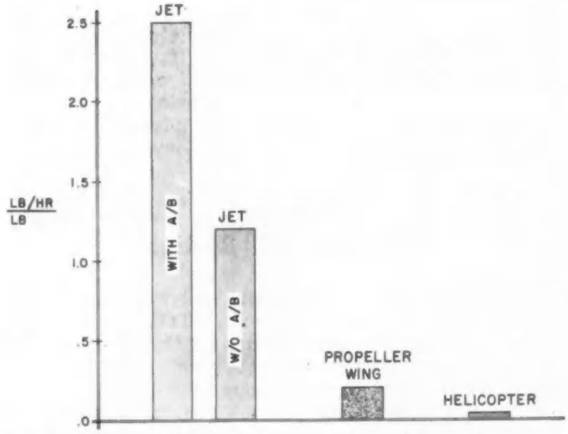
COST VERSUS LIFT ABILITY comparison shows prop-wing types to be most economical. Their cost is only slightly more than that of conventional types. Helicopter's direct operating cost is high because of blade articulation, high vibration level, gear problems.



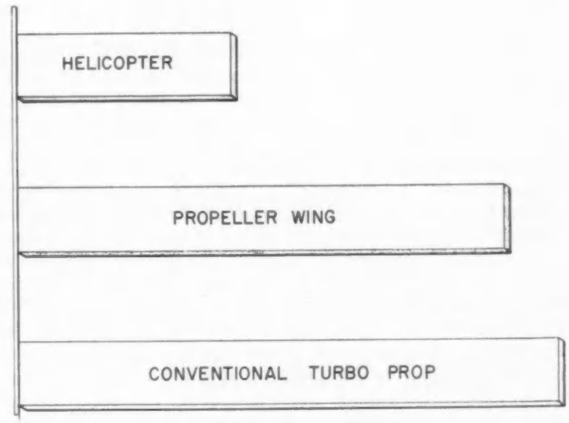
JET IS MASTER OF FAST HIGH FLIGHT. Prop-wing and jet VTOL open up new areas of speed-altitude spectrum of vertical lifting types, which was held so small by helicopter. Altitude possibilities of jet types are limited only by ceiling of earth's atmosphere.

and military reasons dictate that airports should be close to the areas they serve. City planners are having an increasingly difficult time in providing adequate airport facilities for modern air operations near the population centers.

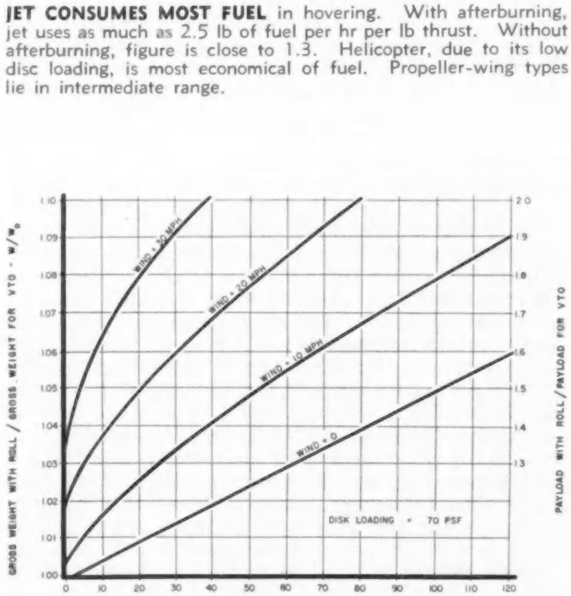
Besides the runway length problem, there is the problem of operating airplanes at high speeds in close proximity to the ground. Precise control of the aircraft is required to minimize the dangers associated with this high speed ground operation. Landing at high speeds means a greater amount of kinetic energy in the airplane at touchdown, which must be absorbed by the brakes. The braking capacity is rapidly being limited by the shrinking confines of the small landing wheels. To offset this braking deficiency, drag chutes or thrust reversers are being used to help in shortening the landing run-out. The higher ground speeds also require a heavier landing gear installation to absorb the greater impact loads.



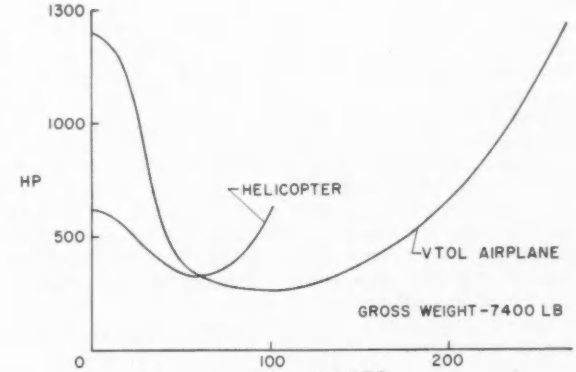
JET CONSUMES MOST FUEL in hovering. With afterburning, jet uses as much as 2.5 lb of fuel per hr per lb thrust. Without afterburning, figure is close to 1.3. Helicopter, due to its low disc loading, is most economical of fuel. Propeller-wing types lie in intermediate range.



HELICOPTER RANGE IS LOW. Pulling big rotor through the air sideways is inefficient. Fixed wing has far better lift/drag ratio. Prop-wing VTOL craft have ranges comparable to conventional aircraft. Range of jets is limited by high fuel consumption.



SHORT GROUND ROLL can greatly increase payload. In 10 mph wind, 100 ft roll boosts allowable gross weight 8% and payload 50%. The higher the disc loading, the less beneficial roll and wind are. Of course, where true VTOL is required, any take-off run is too much.



TYPICAL HELICOPTER AND PROP-WING VTOL plane differ markedly in power requirements. Note that if one of twin engines is lost, helicopter must lose enough altitude to accelerate to 60 knots. High-aspect wing craft must drop only enough to accelerate to 30 knots.

A third justification for VTOL aircraft comes from civil and military operators who are presently looking for a means of increasing flexibility of operation. The incorporation of VTOL capabilities into the medium size transport airplane would allow this airplane to operate out of small flat areas any place in the world without prior preparation. This feature is of particular interest to the military planner.

A convertiplane-type transport, even if it is capable of vertical take-off, will probably operate from an airport with runways several thousand feet long. This will permit the transport to operate with useful loads considerably greater than would be possible if it were forced to take off vertically. It will take off in exactly the same manner as conventional airplanes, but will require relatively short ground runs and be able to climb relatively steeply as compared to conventional airplanes. Landings will be made from a power-controlled approach in which it will be possible to control the glide-path angle and the

speed independently of each other. This will be done by variation of the power and by variation of the thrust direction or the wing incidence or the wing-flap setting.

The landing technique will be to approach along a flight path making only a small angle with the surface, and gradually slow up so that when the airport boundary is reached the speed will have dropped to 30 or 40 knots. From this point under normal conditions of weather and visibility the glide will be steepened, if necessary, and the airplane brought in and flared to a normal airplane-type landing without further speed reduction. However, when weather or airport conditions make it advisable the speed can be further reduced and even brought to zero before touchdown. Only in rare cases will landings be made by stopping with appreciable altitude and descending vertically. Such an approach will be undesirable from the standpoint of fuel and maintenance costs and from the standpoint of safety, but the ability to make such an approach if necessary will add greatly to the pilot's peace of mind and willingness to operate from small airports and to the overall safety and practicability of such operation.

VTOL Improves All-Weather Capability

The power-controlled approach technique will thus make it feasible to operate from small airports under all weather conditions and will eliminate the need for the delays and inconveniences of stacking and use of alternate airports under adverse weather conditions.

Obviously, such aircraft can be used for operation from close-in airports and will be suited for short range and medium range transports. In short range applications, they can be used under conditions that require vertical take-offs and landings. Whether or not they will be superior to or inferior to helicopters in extremely short range and load-lifting operations will depend on such factors as relative ratios of useful to gross weight, relative maintenance costs, relative amount of time spent in hovering as compared to time spent in cruising, and relative ability to operate in all weather conditions. It is probable, however, that developments in stabilization and control devices will make it possible to operate either the helicopter or the vertical flight airplane in all weather conditions and that this consideration will not be an important factor in the choice between the two.

It is probable that vertical flight airplanes will be used widely as business transports because of their ability to operate between close-in airports and from small plots adjacent to factories and business offices.

The suitability of vertical flight airplanes for such military applications as assault transports, supply transports, command and utility transports, reconnaissance and liaison vehicles in which ability to use small unprepared fields is of very great importance, is obvious. There is a great deal of discussion and controversy over the question of whether VTOL or STOL (short, or slow, take-off and landing) aircraft are required for this purpose.

It is believed that this controversy will be resolved with a clear-cut victory for the proponents of each type. It is certainly true that a VTOL aircraft will not be satisfactory unless it has good STOL capabilities. On the other hand, it will probably be found that to be truly operable under the desired conditions an STOL aircraft which can fly vertically with light loads for landing and take-off when necessary or desirable will be sufficiently superior in actual operational use to STOL aircraft not having the VTOL ability that the former type will come into general use.

Both Sides Will Be Right

The controversy will then be resolved by the adoption of STOL aircraft which can VTOL under emergency conditions, a clear victory for the STOL proponents. However, from the other point of view they will be VTOL aircraft with extremely good STOL capabilities, a clear victory for VTOL proponents. A suitable designation for this airplane might be STOVL, slow take-off, vertical landing airplane.

It is undoubtedly true that some penalty will necessarily be paid in payload in order to achieve VTOL capability. It is also true that the airplane will cost more to build than the conventional FTOL (fast take-off and landing) airplane. These facts result from the necessity of using some of the payload capacity for additional powerplant. How much reduction in payload will actually be involved is the subject of considerable study at the present time.

A survey of available engineering estimates indicates that a true VTOL airplane will have about half the load carrying ability of its conventional counterpart assuming use of turboprop powerplants currently becoming available. Obviously, a VTOL airplane used only in STOVL operations need not suffer to such an extent, since it can take off with a larger useful load than its counterpart required to take off vertically—the increase being roughly equivalent to the weight of the fuel to be used on the mission.

As powerplant weight goes down the penalty for VTOL also goes down. It is believed that at some point the further benefit of utilizing lower powerplant weights to provide greater ratios of useful load to gross weight will be less remunerative than using them to provide VTOL capabilities. This is true to an even greater extent when STOVL operation is considered.

VTOL Cuts Runway Length and Cost

Fundamentally, the question of whether to use VTOL, STOL, or conventional (FTOL) fast take-off and landing airplanes for transport operations is going to have to be resolved on the basis of overall economics and utility in which the cost of more expensive airplanes will have to be weighed against the cost and vulnerability of large airports and the cost of passenger inconvenience and dissatisfaction with stacking delays and use of alternate airports in bad weather. It is believed that the time has been reached when designers and operators and municipalities must consider whether additional funds should be expended on large airports or whether the airplanes should be built to operate from small ones.

Low Section Height Oversize Tractor Tires

—provide traction advantages proportional to their loading

F. C. Walters and W. H. Worthington, Deere Mfg. Co.

Based on paper "Farm Tractors and Their Tires" presented at SAE Golden Anniversary Tractor Meeting, Milwaukee, Sept. 14, 1955.

TWO methods of oversizing basic tractor tires are currently available, each having advantages and disadvantages. The use of "low section height tires" provides a third method which combines many advantages of both present methods. Additionally, this method makes it possible to have basic and oversize tires having common outside diameters and rolling radii, without sacrificing tractive performance.

The two conventional methods of oversizing are:

Method 1—using oversize tires having the same bead seat diameter as the basic tire, but with section widths, outside diameters, and rolling radii all larger than those of the basic tire. See Fig. 1. This is the oversizing practice generally followed by all tractor manufacturers today. Fig. 1 shows that this practice results in a considerable increase in rolling radius accompanied by changes in the height of the rear axle, drawbar and integral implement attaching points, and alters the hitch linkage geometry.

Method 2—using oversize tires having smaller rim diameters, but approximately the same outside diameter and rolling radius, and therefore larger section width than the basic tire. Fig. 1 shows this type of oversize tire. This method provides a series of increasing section widths without disturbing the height of the rear axle, drawbar, implement attaching points, or linkage. It has

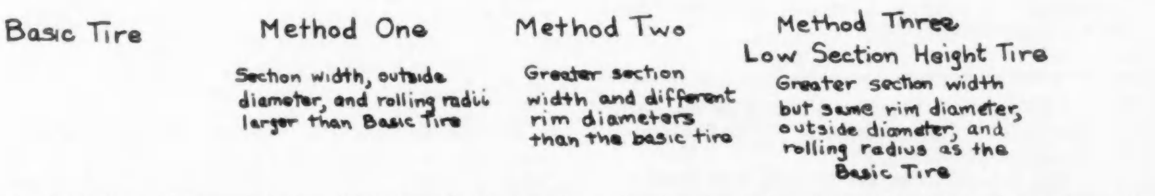


Fig. 1—The discs shown represent tires. On the far left is the basic tire designed for the tractor. Methods 1 and 2 are the two conventional methods of oversizing tractor tires. Method 3, the "low section height" tire is a new suggested method of oversizing tractor tires.

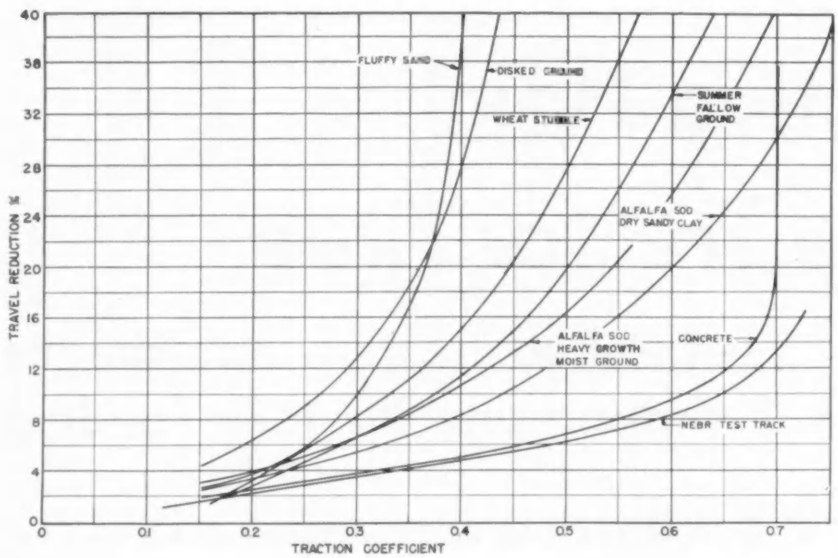


Fig. 2—Traction coefficient varies with soil and surface conditions. These curves are a summary of all the data collected in a series of tests performed to determine the effect of the traction coefficient on travel reduction.

the serious disadvantage of involving different rim diameters and mounting methods.

Providing oversize tires using **method 1** has resulted in such difficulties as tire side wall buckling; side-wise rolling on the rim when operating on a hillside or with one wheel in a deep furrow; increased travel speed without like increase in engine and power take-off shaft speed; reduction in drawbar pull; decrease in tractor stability both laterally and longitudinally; and less satisfactory integral implement performance.

From the viewpoint of tractor and implement performance, use of **method 2**, which provides the desired increase in section width without departing from the outside diameter and rolling radius of the basic tires, becomes very attractive. The principal advantages afforded by **method 2** as compared with **method 1** may be summarized to include:

- Basic and oversize tires can be used interchangeably without significantly affecting travel speed and drawbar performance.
- The distance of the center of gravity of rear mounted implements is determined by the outside diameter of the basic tire rather than that of the largest oversize. With respect to the basic tires, this provision for the use of oversize tires does not affect the longitudinal stability of the tractor-implement combination, maneuverability, the demand on the hydraulic system, and the auxiliary front end weight necessary to provide adequate stability under adverse field conditions.
- The use of oversize tires does not disturb the geometric relationship of the tractor, the ground, and rear or front mounted integral implements.
- Use of an oversize tire does not change the vertical location of the tractor's center of gravity. So the safety of the tractor against backward and sideways upsets is unimpaired.

However, the choice of oversizing method must be qualified by considerations of tire performance also. One series of tests conducted in Arizona indicated that where all tires of a series were loaded with approximately the same basic weight, **method 1** oversizing practice resulted in slightly better traction performance than did **method 2**. Again, other tests made in Arizona under similar conditions showed contradictory results with no advantage resulting from the increase in outside diameter and rolling radius.

Because of the advantages afforded by **method 2**, other ways of attaining these benefits were investigated in the hope that some of the disadvantages of the practice might be avoided.

This investigation resulted in narrowing the selection of oversizes to the following two methods.

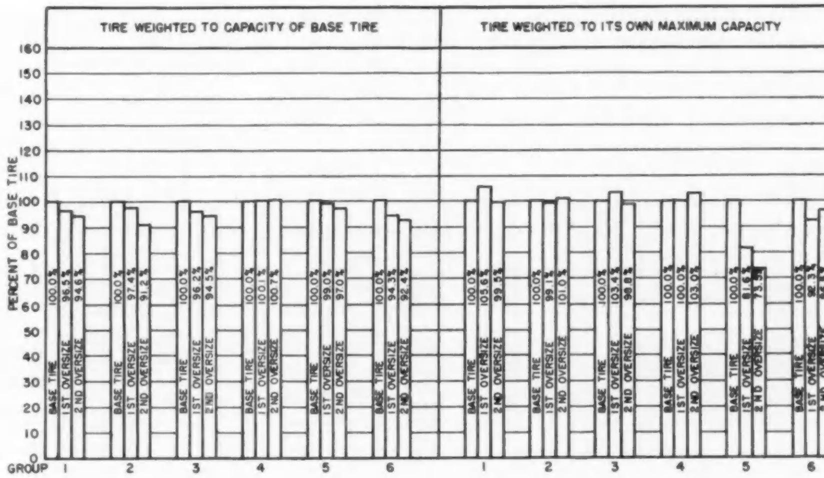
Method 3—providing oversize tires having section widths greater than that of the basic tire, but maintaining the **same rim diameter** and approximately the same outside diameter and rolling radius. Therefore, the ratio of section height to width is smaller on the oversize tires. These tires are called "low section height" tires and are shown in Fig. 1.

Method 4—providing oversize tires having section widths greater than that of the basic tire, while maintaining approximately the same outside diameter and rolling radius, but **smaller rim diameter.** In this type of oversize tire the ratio of section height to width is the same as that of the

This article is based on a report of the SAE Tractor Tire Subcommittee to the SAE Tractor Technical Committee.

This subcommittee has recently formulated a tire and rim program aimed at standardization of low section tractor drive wheel tires for general purpose tractors.

Fig. 3—No appreciable difference in traction coefficient occurs when oversize tires carry the same load as the base tire (left) or when they are loaded to their individual capacity (right). Here traction coefficient is expressed in terms of the base tire at 16% travel reduction.



basic tire. This is accomplished with the conventional tires used in method 2 of Fig. 1.

To evaluate the relative traction performance afforded by tires corresponding to **methods 3 and 4**, cooperative field test programs were undertaken. Various tractive surfaces were used for these tests.

To eliminate the variable of weight carrying capacity of the tires, the comparative evaluation of tire performance is based on traction coefficient, travel reduction, and tire efficiency.

To provide a basis for comparison with much background information currently available, an additional evaluation was made on the basis of tire horsepower and tire net force output.

In conducting all tests involving any specific tire grouping, the individual tires were all operated at the same circumferential velocity, based upon rolling radius. This was done to eliminate any effect that some slight variation in rolling radius might have on tire horsepower. In this way, variations in tire horsepower output would result directly from the difference in section width and not from travel speed. Additionally, all tests were so conducted that at all times sufficient engine power existed to produce "traction stalls" rather than "power stalls." This insures that the resulting data reflect only the tire performance and are not affected by available engine power.

In the field tests, all tires were loaded to approximately the rated capacity of the basic tire at 12 psi inflation.

As would be expected of tests involving different types of soil and surface conditions, varying values of traction coefficient were found. The curves shown in Fig. 2 are a composite of all the data secured on traction coefficients for each soil and surface conditions throughout the entire series of tests. An interesting facet of this study was the close conformity of traction coefficient applying to each soil and surface condition, without respect to tire section width.

Observations of actual farming operations where the tractors were driven by their owners, together with much other field test data, indicate that approximately 15 to 16% travel reduction is common, and is apparently acceptable to the users. Results of other tests indicate that where high tire slippage results in a tendency to "dig in," maximum traction output occurs at approximately 45 to 50% travel reduction. Using this as a basis for further analyzing performance data secured during these tests, the charts shown in Fig. 3 and Fig. 4 were prepared. Table 1 lists the tire sizes used and their groupings.

Fig. 3 shows the effect of section width on traction coefficient. The left portion of the graph shows values of traction coefficient when the oversize tire was carrying the same load as the basic tire. The right portion shows values of traction coefficient where each tire was loaded to its capacity at 12 psi inflation pressure.

As a result of these tests, the following conclusions are evident:

1. When the basic and oversize tires were loaded to the rated capacity of the basic tire, the performance of the basic tire was slightly better than the oversize tire.

2. When each tire was loaded to its individual capacity, no significant difference was found among

Table 1—Tire Dimensions at 12 lb. Pressure

Test Group	Tire Size	Ply Rating	Rim Width-in.	Section Width-in.	Outside Diameter-in.
I and II	12-38	6	11	13.2	61.5
	38-13	6	12	13.9	61.84
	38-14	6	14	15.47	61.81
	13-36	6	12	14.4	62.0
	14-34	6	13	16.0	62.2
III and IV	14-34	6	14	16.23	62.28
	34-15	8	16	18.22	62.49
	34-18	8	18	20.55	62.87
	15-30	6	14	17.87	61.38
	18-26	8	20	23.17	62.51
V and VI	11-28	4	10	11.9	49.8
	28-12	4	11	13.1	49.8
	28-13	4	12	14.4	49.8
	12-26	4	11	13.1	49.6
	13-24	4	12	14.4	50.0

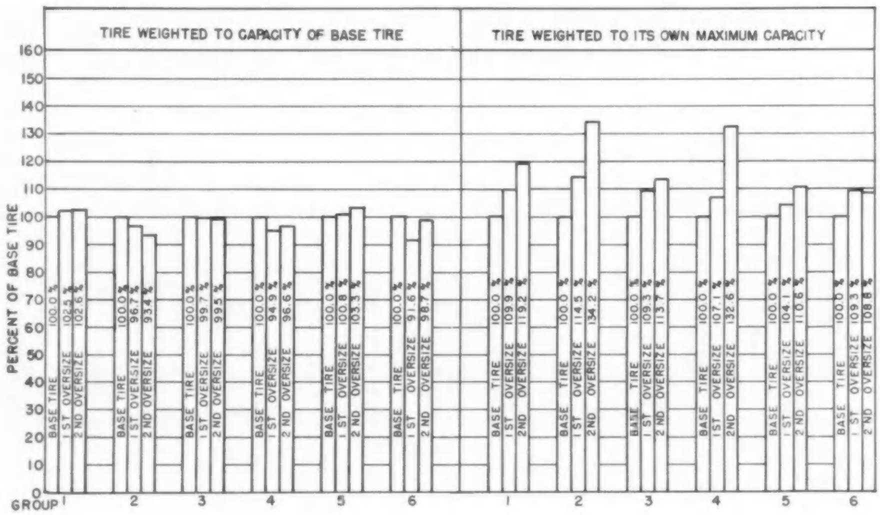


Fig. 4—Here net force output is expressed in terms of the base tire at 45% travel reduction. No increase in output results when the oversize tires are weighted to the capacity of the base tire (left). When the oversize tires are weighted to their maximum capacity (right) the increase in net output is apparent.

the values of traction coefficient of any of the tires tested.

3. When floatation is adequate, the traction advantages resulting from the use of oversize tires are directly proportional to their loading.

A study of the base tire and the oversize tires at 16 and 45% travel reduction and with loading only to the capacity of the basic tire showed little difference in net force output. See Fig. 4. When any oversize tire was loaded to its full rated capacity, the net force output was greater than that of the basic tire, varying directly as the tire loading.

Referring to Fig. 5, the effects of the use of oversize tires on tire horsepower become apparent. In general, the same trends exist as those characterized by a comparison of net force output. Where any difference was found, it was magnified by the change in travel reduction (slippage) characteristics. The benefits gained from increased tire loading are evident. Here again, no significant improvement in performance is gained through the use of oversize tires, unless advantage is taken of their greater weight carrying capacity.

Data concerning the rolling resistance for various tractive surfaces of both the front and rear wheels of the tractor was obtained during the test program. This data is summarized and recorded in the complete paper.

This analysis of the field performance of basic and oversize tires with common tread designs, outside diameters and rolling radii, operating under a wide variety of carefully controlled soil and surface conditions led to the following conclusions:

- The ability of an oversize drive wheel tire to increase tractor performance is largely a function of any additional weight that can be safely carried by the tire and not the result of section size or configuration.
- Where the weights carried by the various tires are nearly equal, there is no significant differ-

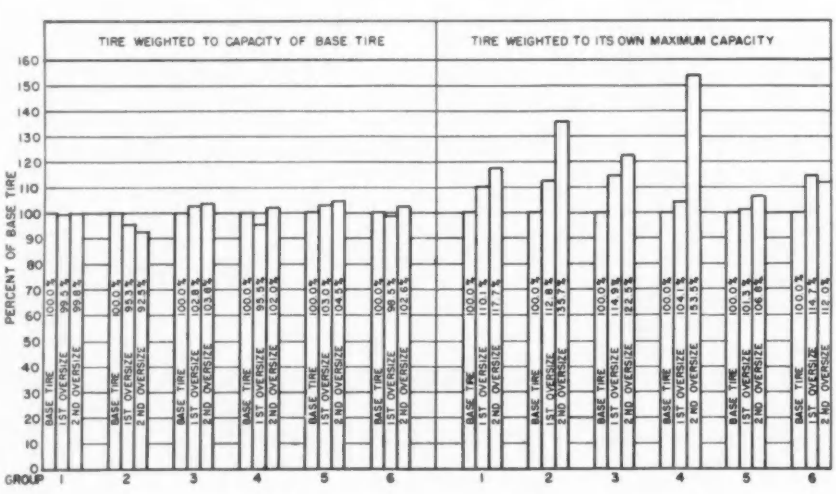


Fig. 5—Here the effects of the use of oversize tires on tire horsepower become apparent. When the oversize tires are weighted to the capacity of the base tire (left) the difference in tire horsepower, expressed in terms of the base tire at 16% travel reduction, is negligible. When the oversize tires are weighted to their own maximum capacity (right) the tire horsepower is considerably improved.

ence in performance characteristics of comparable low section height tires (method 3) and conventional design oversize tires (method 2).

- Section width has little effect on traction coefficient or tire efficiencies. What slight effect did exist, favored the smaller section width tire.
- Tractionwise, unless advantage is taken of the greater weight carrying capacity of the oversize tire, little to no advantage is gained through their use.
- Because performance is directly dependent upon the weight carried by the tire, oversize tires with conventional section configuration have a performance (tractive effort) potential slightly greater than tires of low section height configuration. This is because the volume available for carrying liquid ballast and the rated load capacity of the former are greater than the latter.
- It has been demonstrated that the many advantages resulting from the use of basic and oversize tires with common outside diameters and section heights (method 3) may be secured without sacrificing tractive performance as compared with oversize tires of conventional section configuration (method 2).

For complete paper (in multilith form) on which this abridgment is based, write SAE Special Publications. Price: 35¢ to members, 60¢ to nonmembers.

Jet Engine Buckets . . .

. . . still best made by precision forging. But more complex composition of alloys and greater intricacy of design increase forging problems.

Based on paper by **Stephen G. Demirjian**, Small Aircraft Engine Department Laboratory, General Electric Co.

THE complex compositions of the more recently developed high temperature alloys is also making conventional melting more difficult. More heats are "lost" at melting than at any other point, according to suppliers of these alloys. Thus melting is the most critical point in alloy manufacture. Heats that are improperly melted will contribute to cracking and high processing costs in the forging of buckets because undesirable constituents are present.

Vacuum melting of the present nickel base alloys with aluminum and titanium additions is expected to result in cleaner and more forgeable alloys, with noticeable improvement in fatigue strength, stress-rupture life, and ductility.

In the field of jet engines, the cobalt-base and nickel-base alloys are most widely used. The cobalt-base S-816 alloy and the nickel-base Inco 700 are arc melted in the conventional manner. M-252 and Udimet 500, both nickel-base, are vacuum induction melted. M-252 also has been vacuum melted, using the consumable electrode process.

Vacuum melting of M-252 has resulted in longer stress-rupture life and improved ductility and forgeability, while overall properties are superior to the air melted M-252. However, to reduce the spread in values of vacuum melted M-252, further intensive work is being done with the melting technique itself as well as in the conversion of ingots to bars. Vacuum melting is still relatively new as a method for making high temperature alloys on a production basis. Hence it is only a matter of time before these objectives are accomplished.

Based on experiences with M-252, it can be assumed that vacuum melted Inco 700 will be superior to air melted alloy. A comparison of properties between Udimet 500 and Inco 700, both vacuum melted, will be interesting. (Paper "Wrought Jet Engine Bucket Alloys" was presented at SAE Annual Meeting, Detroit, Jan. 10, 1956. It is available in full in multilith form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)

Based on Discussion

F. N. Darmara
Utica Drop Forge & Tool Corp.

Vacuum melting has brought a new dimension of control, both in accuracy of chemical composition and accuracy of melting practice. Still, even with this advanced and accurate technique, one cannot say that just because a material is vacuum melted it is automatically good. In order to maintain high standards of quality the melting practice must be controlled very accurately and must be correct for the alloy being melted.

Even though melting practice is extremely important, the forging must be held to closely controlled correct procedure. We have seen material from the same heat forged under slightly varying conditions exhibit low life with high ductility and vice versa. It is not clearly understood whether this variation is due to the effect of hot working on the material itself or on its response to heat-treatment.

C. G. Bieber
International Nickel Co.

Vacuum melting of Inco 700 has not been as promising as hoped. The greatest improvement thus far, especially in ductility, has been produced by heat-treatment.

An increase in the titanium and aluminum (above 3%) contents has resulted in greater properties for Inco 700.

About SAE Members

JORDAN E. JOHNSON, application engineer (Aircraft Products), of Vickers, Inc., has moved activity from the main office in Detroit to Silver Spring, Maryland.

DUANE R. PROSSER is now a mechanical engineer for U. S. Navy Department, Bureau of Aeronautics. Formerly he held the same position for U. S. Navy Electronics Laboratory, Point Loma, San Diego.

JAMES E. VEVERA has accepted a position as a flight test engineer with Convair, Division of General Dynamics Corp., San Diego. His new responsibilities will be planning missile test site facilities, equipment, and operations. He was formerly test director of Northrop Aircraft, Inc.

ROBERT L. GATES, formerly plant metallurgist for Wooster Division, Borg-Warner Corp., has accepted a position with United Steel Fabricators, Inc., in Wooster, as a project engineer.

RALPH L. SKINNER, JR. is now eastern sales representative and engineer for Skinner Seal Co. He had been with Flexible Seal Co. as manager and partner.

HARRY C. DOANE, Buick Motor Division assistant chief engineer, has become assistant to **CHARLES A. CHAYNE**, General Motors vice-president in charge of Engineering Staff.

In announcing the appointment, Chayne said Doane will serve in an engineering liaison capacity with Automobile Manufacturers Association committees, other inter-industry technical groups, and with the American Association of Motor Vehicle Administrators.

Recently Doane was named chairman of the Automobile Manufacturers Association Vehicle Lighting Committee.

HANNES RUESCH has joined William Christensen Co., Detroit, as a development engineer. He had been with American Motors Corp. as senior layout man.

FRANK A. TIEDGE, formerly zone manager (sales), has been appointed staff assistant to the general sales manager of Chrysler Corp.'s Dodge Division in Detroit.

JACK F. HOCKMAN has joined Chrysler Corp. Product Cost Control Department as a methods analyst. He had been with Burroughs Corp., Detroit, as a plant layout engineer.

JOHN KURELEK has been named mill engineer for Standard Tube and T. I., Ltd., in Woodstock, Ontario. He was formerly assistant engineer of Bickle Seagrave, Ltd., in the same city.

OSCAR A. LEVI has joined Ryan Aeronautical Co. as a flight test engineer "A". He was formerly with Sikorsky Aircraft Division, United Aircraft Corp., as a flight test engineer.

JAMES R. JOHNSON is now employed as account representative—assigned to Ford Truck Group—with J. Walter Thompson Co. in Detroit. Johnson was previously with GMC Truck & Coach Division, Kansas City, as district manager.

EARL W. BLANKENHEIM, formerly equipment supervisor for the City of Cudahy, is now automotive supervisor of Oscar Mayer and Co., Madison, Wis.

MERL R. WOLFARD has applied his long experience in solving specific research problems to the solving of a much broader—and more difficult problem—namely, "How does the mentality of an engineer work at a creative problem?" The result has been a new book, "Thinking About Thinking."

By approaching thinking on an energy basis, the author points out, skepticisms cannot be analyzed constructively. To encourage cogent thinking, the author suggests that we replace the time-worn phrase, "trial and error," by the phrase, "trial and selection."

He adds, "Unless one can select something besides 'error' out of a long series of trials, he is getting nowhere . . . in engineering progress the phrase, 'trial and selection,' expresses quite neatly and exactly the procedure which is followed." The volume is published by Philosophical Library, Inc., New York City, 1955.

WILLIAM J. SKELLEY has been named aeronautical design engineer of Fairchild Aircraft Division, Fairchild Engine & Airplane Corp., Hagerstown. Previously he was with Bell Helicopter Division in Fort Worth as a designer.

DONALD L. WHITNEY is now an aircraft assembler "A" for Boeing Airplane Co., Wichita Division. He was previously a functional tester "B."

EARLE F. COX has been appointed assistant chairman, board of directors, for the Matisa Equipment Corp., Chicago. He was previously management consultant of Booz, Allen, and Hamilton, Inc., in Chicago.

CHARLES H. WILLIAMS, JR. of Glenn L. Martin Co., has been named manager, service and test, of Denver Division. He had been operations manager in Baltimore.

BURT C. MONESMITH, vice-president and general manager of the California Division, Lockheed Aircraft Corp., was recently presented a 10-Year Pin by the president of the corporation. The presentation was a surprise ceremony.

Monesmith joined Lockheed in 1946 as factory A assistant works manager. He served in that capacity until August of 1948 when he became works manager. In October, 1949, he was made assistant to the vice-president, manufacturing, and by May, 1950, he had become manufacturing manager.

In 1952 he was elevated to vice-president and manufacturing manager and in September of that year he was made general manager of the California Division.

ELLIS W. TEMPLIN spent the month of June in Hawaii this year, visiting the islands of Oahu, Maui, Hawaii, and Kauai. An SAE past vice-president for T&M and a past SAE councilor, Templin visited with many of the current officers and members of the Hawaii Section during his stay in the islands. He expected to return to Los Angeles in July.

CARL L. HECKER, first vice-president of the Oliver Corp., has taken on additional responsibilities of general sales manager of his company. Hecker has been active as a member of the SAE Production Activity. In 1954, he was co-chairman of the Production Forum held in conjuction with the National Production Meeting in Chicago that year. And quite prophetically, he played the role of the sales manager of the mythical Helitrac Co. in a skit at this year's Annual Meeting pointing up top management's approach to automation.

ALBERT B. WILLI, JR. has been promoted to executive engineer of the Federal-Mogul Division of Federal-Mogul-Bower Bearings, Inc. He was assistant chief engineer in charge of sales engineering.

Willi will continue to direct the sales engineering activities and will also supervise service and product engineering under the direction of chief engineer **H. F. DIXON.**

EDUARD BARUCH has been appointed president of Heli-Coil Corp., Danbury, Conn.

Baruch was an important figure in the formation of Heli-Coil Corp. and has served as a vice-president and director of the company since 1951. He has been executive vice-president since January, 1956.

He is also a director of Premmco, Inc., Resources and Facilities Corp., and Dynamic Industrial Products.

L. IRVING WOOLSON, vice-president of the Chrysler Corp. and president of its De Soto Division, has been elected to the board of the Chrysler Corp. Election took place at the last annual stockholders' meeting.

Woolson has been a member of SAE since 1937 and has been a member of the Detroit Section governing board in various capacities. He was chairman of the Detroit Section in 1950–1951.

COLONEL EARL W. HAEFNER has been appointed assistant to the president of Borg-Warner International Corp.

He joined Borg-Warner International from the General Staff of the United States Army, where he supervised activities in engineering standards, specifications, and standardization for the Department of the Army. This was coordinated with the Department of Defense Standardization Program for the manufacture of products by industry for the armed services, and involved the supervision of production programs in the factories of suppliers to the Army, Navy, and Air Corps.

Col. Haefner's new activities will involve liaison between Borg-Warner International and its foreign operating subsidiaries.

He had previously been manufacturing coordinator for the corporation.

New Diamond T Executive Changes

Hansen

Z. C. R. HANSEN has become president of Diamond T Motor Car Co. During his three years with the company, he has successively been vice-president and director of sales, executive vice-president, and now, president.

Hansen joined Diamond T in Chicago in 1953 from Portland, Ore., where he had been general manager of the Diamond T dealership, Automotive Equipment Co.

Wallace

R. C. WALLACE, previously chief engineer, has been elected vice-president in charge of engineering. He has been with Diamond T since 1947, originally as executive engineer.

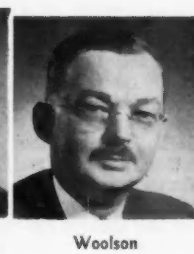
Wallace was SAE vice-president representing Truck and Bus Activity in 1954.

Templin

Hecker

Willi

Baruch



Woolson

Haefner

GAYLORD W. NEWTON is now manager—applications engineering for General Electric Co. in Cincinnati. He was formerly chief engineer—test facility, Aro, Inc., of Tullahoma.

DR. C. G. A. ROSEN, 1955 SAE president, has been awarded a second honorary doctor's degree.

Capital University, Columbus, Ohio, conferred the degree, Doctor of Laws, upon Past-President Rosen at the June 4 commencement exercises.

Said Capital University President H. L. Yochum: "Capital University is happy to give this recognition to you on the basis of your outstanding achievements and services in the field of engineering, not only in its technical phases but in its broader aspects, particularly in terms of human values."

Dr. Rosen is consulting engineer to the president, Caterpillar Tractor Co.

PAUL R. GLAZIER is to head a new engineering department of the Torrington Co.'s Specialties Division in Torrington, Conn. Glazier had been chief product engineer for the Bearings Division of Torrington since the spring of 1955. He joined Torrington as a trainee in the Needle Division and was transferred to the Research Department in 1938.

ANTHONY J. ZINO, JR. has been appointed vice-president in charge of sales for Dixon Sintaloy, Inc., Stamford, Conn., subsidiary of the Joseph Dixon Crucible Co., Jersey City. From 1939 until 1941 Zino was New York sales engineer and later New York district sales manager for the Lubri-Zol Corp. of Cleveland. He became Eastern division lubricants sales manager for E. F. Houghton & Co. of Philadelphia when the retail division of Lubri-Zol was absorbed by Houghton. In 1947 he joined the Swan-Finch Oil Corp., New York, as assistant industrial sales manager, and was named assistant to the president in 1950. A year later he moved to the Joseph Dixon Crucible Co. as general sales manager, and was made sales manager for Dixon Sintaloy, Inc., in 1953.

ALBERT O'BRIEN BEMISS has joined Hancock Electronics Corp. as a mechanical engineer. He had been with Ampex Electric Corp. of Redwood City in a similar capacity.

RICHARD L. HUNT has become manager—Marine Section, Export Department for the Worthington Corp. For the past year he has been serving as engine specialist for the Export Department.

Somebody Told Me

by R L Sackett

When **GEORGE McCAIN** retired from Chrysler he moved six filing cases of SAE Standard and SAE committee work to his home. That comes close to Exhibit "A" for SAE interests. And O! yes, get **GEORGE** to tell you about the winter he rode atop a Jeep platform taking pictures at AMA's Clintonville winter driving tests with a 25 mph wind and a -30 F temperature. Took the skin off his tongue.

—— STM ——

Head of the United States Auto Club is Past-President **ART HERRINGTON.** USAC took over all AAA racing, hill climbing, economy runs, etc. Western zone supervisor for USAC is **L. A. LESOVSKY,** Passenger Car vice-chairman for SAE's Southern California Section. **LESOVSKY'S** business is race car engineering. He built the car which finished in ninth place at this year's Indianapolis 500 Mile Race.

The car left Los Angeles by air freight on a Thursday; arrived in Indianapolis Friday night. On Sunday the engine was started for the first time and qualified at over 142 mph. This was only one week prior to the race.

More USAC. **MARVIN RUSSELL,** past Southern Cal. Section chairman, was on USAC technical committee for Mobilgas Economy Run.

—— STM ——

Fan Mail . . . **T. G. DREWES,** American Brakeblok, nominates **U. B. GRANNIS, JR.** and **CARL RASMUSSEN** for the SAE Ski Team. With the short summer we've had, might as well talk skiing.

—— STM ——

Did you see **DOCTOR R. F. "BOB" THOMSON,** head of metallurgy, GM Research, on Wide-Wide-World TV with Dave Garroway from GM's fabulous new Tech Center, Sunday, May 20? Slick performer, eh? Also **BOB** is 1956 chairman of our ISTC Panel C—Automotive.

—— STM ——

If Cleveland's nurseries haven't caught up with it yet, there should be big business 'cause **CARL GOLDBECK;** bet-he-has-a-tennis-court **NED BROWN,** and **BOB STEENECK** have new homes and are going in for lush landscaping.

—— STM ——

RALPH TEETOR (SAE president 1936) is bragging about a brand new grandson, Ralph R. Meyer. Prexy **RALPH** and Mrs. T. cruised the Mediterranean this spring. They made Greece, the Gaza Strip, and the other hot spots of the Near East just before the big blow-up.

—— STM ——

April Earthmoving Conference in Peoria was the first for **CHARLIE LINCOLN,** Saginaw Steering Gear chief engineer. He told the boys it was the best SAE meeting he'd ever attended.

—— STM ——

You should have seen staid Technical Board members clambering over and peering into innards of old Thomas Flyers, Briscoes, Carter Cars, Scripps-Booths, Daimlers, Rolls Royces, old Tri-Motored planes, Fokkers, old Nichols and Sheppard steam threshing machines, etc., as Chairman **BOB KOHR** of the Board played host at Ford's Greenfield Village Museum the afternoon following the May 24 Technical Board meeting in Detroit. (See photo on p. 88.)

—— STM ——

JACK NELSON, Chicago Section chairman, has a full time 18 weeks-a-year job teaching in the Standard of Indiana training school for sales engineers.

—— STM ——

Reports around Cleveland this spring are that it was "Please - shake - gently Adams". That is, **JOE ADAMS,** Production Forum chairman. The do-it-yourself bug bit *Joe* the day before the Forum. So, the BX cable on the 220 volt line he was putting in for his wife's new electric range bit back and cut his right fore finger.

—— STM ——

Past SAE President **JIM CRAWFORD,** on to Detroit for the GM Tech Center dedication, says he's up to his ears in activities back in La Jolla, Calif., what with exhibits of his top level paintings, two or three local Civic Boards and a number of organizing projects. **JIM** was in fine fettle. The Tech Center was launched under his administration as GM's V.P. of engineering. He should be proud. And is.

Bement

McCracken

Hershey

Fenn

HERMAN H. BEMENT has recently joined the military requirements department of Aircraft Engine Operations, Sales, and Contracts, Allison Division, GMC, as a field engineer on turbo-prop and turbo-jet engines. Prior to leaving the Naval Service, Bement was assigned as a project officer in the Bureau of Aeronautics and an aircraft maintenance officer with the fleet.

FRANKLIN Q. HERSHEY is now manager of industrial design for a new section of Kaiser Aluminum & Chemical Corp. at Oakland, Calif.

The new section, in Kaiser's Product Development Department, is to coordinate styling as an integral part of the development of new and broader aluminum applications.

From 1952 to 1955 he was a chief stylist for Ford Motor Co.

JAMES McCRACKEN has joined the Ferry Cap and Set Screw Co., Cleveland, as assistant district sales manager of its Detroit Office.

McCracken has been located in Detroit for the past 13 years, formerly with Thompson Products, Inc., as assistant sales manager of its Michigan Division, and more recently with Trico Products Corp.

CLAUD FENN has become a vice-president of Clark Equipment Co.

Fenn, who joined Clark in 1934, has been in charge of the company's plant at Buchanan, Mich., for the past eight years. He will continue in this function. Prior to his association with Clark, he was associated with Studebaker Corp., Pan American Airways, and South Bend Tool & Die Co.

Obituaries

CARL W. JOHNSON

Carl W. Johnson, one of the founders of the Cleveland Graphite Bronze Co. and senior vice-president of Clevite Corp., died June 5 in Henry Ford Hospital in Detroit.

Johnson entered the hospital for an emergency operation May 15.

Born at Redwing, Minn., in 1886 and reared on the family farm, Johnson was largely self-educated and his first job was as a laborer in the roundhouse of the Chicago, St. Paul, Minneapolis & Omaha Railroad at St. James, Minn. He later became a fireman and engineer for the road and carried a card in the Brotherhood of Locomotive Engineers all his life.

He sold schoolbooks throughout the United States and Canada and then became an oil salesman in Chicago. His next job was as a machinist with the Dann Products Co., which brought him to Cleveland in 1917.

The Dann firm was the predecessor of Cleveland Graphite Bronze and when that company was organized in 1919 Johnson became factory manager. Later he shifted to the sales department and became sales manager. He was made vice-president in charge of sales in 1940.

He became senior vice-president of Cleveland Graphite Bronze in 1948 and retained that title and post when Clevite was organized in 1952.

Johnson was known as a sportsman and had hunted and fished all over the world. His clubs included the Union, Mid-Day, Tavern and Shaker Heights Country Clubs here and the Detroit Athletic Club, Detroit Club, Bloomfield Hills Country Club, Recess Club, St. Bernard Fish and Game Club in Quebec and the Mud Creek Club in Ontario.

He was a director of a number of Cleveland companies, besides Clevite, among them Standard Products Co., Selective Securities, Parker Appliance Co., and the Ferro Enamel Corp.

He had been a member of SAE since 1922.

SAE National West Coast Meeting

Mark Hopkins Hotel
San Francisco, Calif.
August 6-8, 1956

General Chairman: **John R. MacGregor,** California Research Corp.

Monday, Aug. 6

Papers entitled: **Fuel for Thought;** and **Truck Mufflers—Temperatures, Materials, and Life.** Narration of three silent movies on the theme —**Getting the Most Out of Your Equipment.**

Tuesday, Aug. 7

Subjects covered: **An Economic Analysis of the Diesel Field; Orion—A Gas-Generator Turbo-Compound Engine; Tires and Horsepower; Better Truck and Bus Brakes;** and **Braking Systems.**

Wednesday, Aug. 8

Topics offered: **Six Million Miles Experience with Gas Turbine Locomotives; Notes on a Turbocharged Two-Cycle Diesel Engine; Heavy Fuel in High Speed Diesel Engines;** and **Observations on 25,000 Hours of Operation with the Free Piston Engine.**

Featured Social Activities:

Tuesday evening—Banquet with a talk by L. B. Lundborg, vice-president, Bank of America, entitled **"Polish Up Your Mirror"**

Thursday, 7:30 a.m.—**All-day trip on the canted deck carrier Philippine Sea** starting from Alameda Naval Base. Airplane take-offs and landings will be demonstrated. Admission by reservation only. Limited to 250 persons.

TECHNICAL COMMITTEE *Progress*

O-Ring Panel Gets Data on Metal Boss Seals

METAL boss seals give very good service in 3000 psi—400 F hydraulic systems if the parts they seal are dimensionally accurate, it was reported at the March 28–29, 1956, meeting of the O-Ring Panel of the SAE Aircraft Accessories and Equipment Division.

The seals are deformable metal rings designed to prevent leakage around hydraulic fittings (with standard AND10056 or AND10057 fittings ends) used in AND10050 bosses. (The AND numbers refer to Army-Navy drawings.)

The metal seals were developed by Wright Air Development Center for applications where o-rings of organic compounds can't stand the prevailing temperatures, pressures, or the deterioration caused by the hydraulic fluids used.

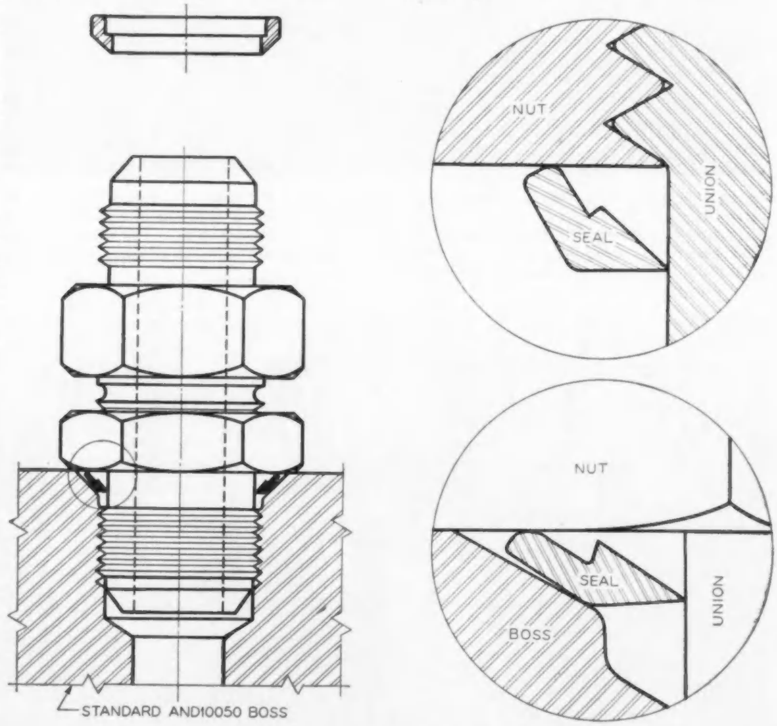
Inaccurate Fittings Harm Seals

WADC engineer Paris Paraskos reported to the O-Ring Panel on tests involving assembly of metal boss seals with various fittings retrieved from supply stock. No difficulties were encountered, he said, in assembling the seals with various fittings that conformed to applicable AN and AND standard drawings.

However, with certain fittings that inspection later revealed did not conform to specifications, the seal was not tight. The trouble lay with inaccuracies in the diameters between which the seal goes and with the presence of tool marks on bearing surfaces.

Changes have been proposed for the AND10056 fitting end to insure satisfactory installation of metallic seals. The changes include addition of a longitudinal dimension "Q" which is the thread relief length, and a note that the bearing surface of the nut "shall be free from burrs, longitudinal and spiral tool marks, and shall be smooth, except that annular tool marks will be allowed to 32 microin. RMS max."

To manufacturers interested in using or making metal boss seals, WADC offers sample seals and production drawings.



METAL BOSS SEALS are deformable rings intended to prevent leakage around hydraulic fittings used to connect lines with bosses on engines and on other units. The ring is applied to the fitting and the fitting is screwed into a special threaded tool to preset the ring. Then the fitting, with ring still pressed snugly against it, is screwed into the boss. Upper circle at right shows ring when it has been partly deformed to fit. Lower circle shows ring after full deformation.

Committee A-9 Confers at Harvard On Aircraft Air Conditioning

Dr. Louis F. Johnson, Jr., W. W. Reaser, Dr. Charles A. Berry, Dr. Robert R. Burwell, Dr. Ross A. McFarland, and Dr. Dwight O. Coons. Reaser, of Douglas Aircraft, is chairman of Committee A-9. McFarland is a member of the faculty of Harvard School of Public Health. The other men are candidates for advanced degrees in aviation medicine aspects of public health at Harvard. All were speakers at the Committee A-9 meeting.

ON May 7 and 8 Committee A-9, Aircraft Air Conditioning Equipment of the SAE Aircraft Accessories and Equipment Division, held its meeting at the Harvard School of Public Health, Boston, Mass. Twenty-nine members and 17 interested observers attended.

W. W. Reaser, Chairman of Committee A-9, first introduced Prof. Ross A. McFarland of the Harvard School of Public Health, who had arranged the program. Dr. McFarland introduced Dr. John C. Snyder, dean of the Harvard School of Public Health, and Prof. Philip Drinker, chairman of the Department of Industrial Hygiene, who welcomed participants to Harvard.

Dr. McFarland gave the first paper, "The Influence of the Loss of Cabin Pressure on Aircrews and Passengers." He pointed out the adverse effects of changes in partial pressures, by explaining the deteriorating effects of inhaling ambient air at low partial pressures. These effects are due primarily to an hypoxic condition which is produced in the body, and he outlined the physiological changes which occur in the central nervous system and the organs of special sense when hypoxia is produced acutely.

Four physicians in the aviation medicine training program at Harvard, which is under the direction of Dr. McFarland, also gave talks on current problems. Charles A. Berry, Capt. USAF (MC), spoke on "The Effects of Changes in Total Pressure on Aircrews

Participants in Committee A-9's meeting held at the Harvard School of Public Health.

and Passengers." He outlined the experience of pressurization failures in cabins of conventional transports and related, from experience with Air Force personnel, the serious consequences of pressure failures on jet transports.

Robert R. Burwell, Capt. USAF (MC), spoke on "Jet Transport Cabin Environment and the Transportation of Patients and Ill Passengers." He pointed out that while the record of civilian airlines to date has been good in regard to the non-aggravation of pre-existing illness of passengers, the problem of jet operations is complicated by the factor of low partial and total pressures on the medical illnesses which many passengers boarding transports have been demonstrated to have.

Louis F. Johnson, Jr., Major USAF (MC), spoke on "The Effects of Certain Toxic Agents on Altitude Tolerance." He demonstrated that the effects of carbon monoxide inhaled and absorbed by the hemoglobin of the blood, even in very minute quantities, can decrease the tolerance of altitude of an aircrew member by many thousands of feet.

Wing Commander Dwight O. Coons, RCAF, spoke on "The Physiologic Effects of Commonly Encountered Toxic Agents in Aircraft." He outlined the different modes of action on the human body of respiratory irritants and poisons and described their deleterious effects.

On Tuesday, May 8, the Conference was opened by Dr. Leslie Silverman, associate professor of industrial hygiene engineering, who spoke on "The Measurement of Air Contamination in Small Occupied Quarters." Dr. Silverman emphasized techniques of measurement and gave practical demonstrations of equipment. Dr. C. P. Yaglou, professor of industrial hygiene, spoke on "Ventilation Requirements for Cigarette Smoke."

Professor Paul Sandorff, Department of Aeronautical Engineering, Massachusetts Institute of Technology, concluded the morning session with a description of the engineering problems to be solved before man conquers space, in his talk on "The Problems of Cabin Air Conditioning for Flight at Very High Altitudes."

SAE National Meetings

1956

August 6-8
West Coast Meeting
Mark Hopkins Hotel,
San Francisco, Calif.

September 10-13
Tractor Meeting and
Production Forum
Hotel Schroeder, Milwaukee, Wis.

October 2-6
Aeronautic Meeting, Aircraft
Production Forum, and Aircraft
Engineering Display
Hotel Statler, Los Angeles, Calif.

October 10-12
Transportation Meeting
Hotel New Yorker
New York, N. Y.

November 1-2
Diesel Engine Meeting
The Drake, Chicago, Ill.

November 8-9
Fuels and Lubricants Meeting
The Mayo, Tulsa, Okla.

1957

January 14-18
Annual Meeting and
Engineering Display
The Sheraton-Cadillac
and Statler Hotels,
Detroit, Mich.

March 5-7
Passenger Car, Body, and
Materials Meeting,
The Sheraton-Cadillac,
Detroit, Mich.

March 20-22
Production Meeting and
Forum, Hotel Statler,
Buffalo, N. Y.

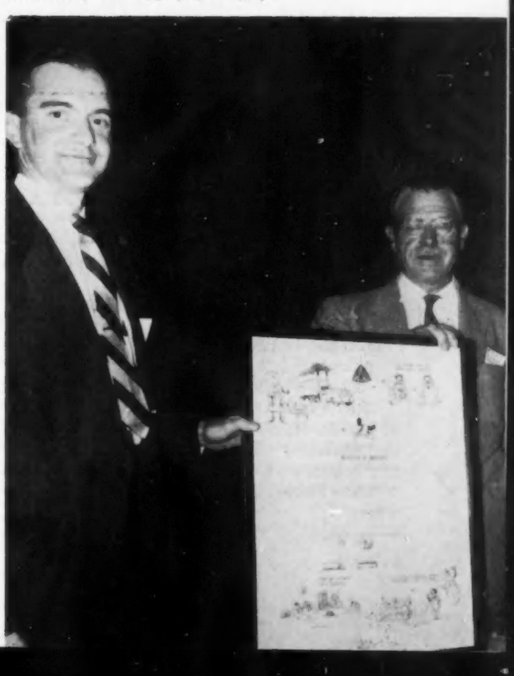
April 2-5
Aeronautic Meeting,
Aeronautic Production Forum,
and Aircraft Engineering Display
Hotel Commodore, New York,
New York

June 2-7
Summer Meeting
Chalfonte-Haddon Hall,
Atlantic City, N. J.

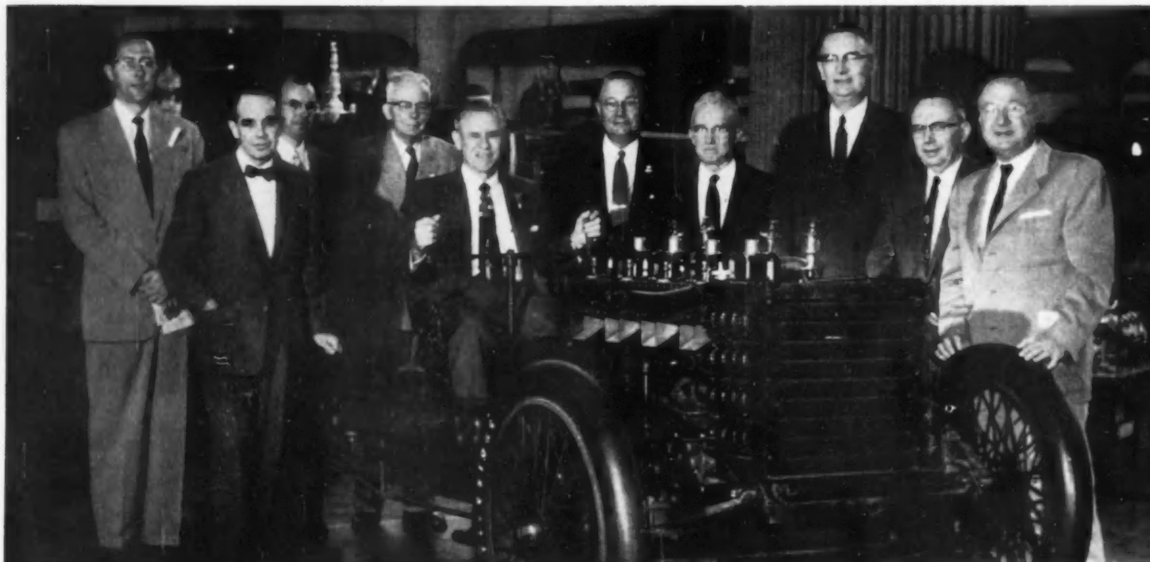
New SAE Vice-President

ROBERT E. JOHNSON has been chosen by the SAE Council to fill the unexpired term of the late Andrew L. Pomeroy as 1956 SAE Vice-President for Aircraft Powerplant. The Council named Johnson at its June 7 meeting in Atlantic City and he took office immediately. He is chief field engineer, Wright Aeronautical Division, Curtiss-Wright Corp., and has his headquarters at Wood-Ridge, N. J.

W. P. Michell (right) was presented with a certificate "in unanimous appreciation of the SAE Truck and Bus Technical Committee (and its predecessor, the Motorcoach and Motor Truck Committee) for 11 years of outstanding leadership." The presentation was made by **L. C. Kibbee** at a testimonial dinner during the Summer Meeting. Michell has been chairman of the Committee since 1944. Kibbee succeeds him as chairman.



Tech Board Inspects Ford Museum



FROM THE FUTURE TO THE PAST . . . that was pretty much the order of things for the SAE Technical Board at its May meeting in Detroit.

The Board spent a full morning discussing and reviewing technical committee reports and passing upon proposed standards and specifications. Many are automotive engineering guideposts for future designs. In the afternoon, Board members were the guests of Chairman R. F. Kohr at the Henry Ford Museum in Dearborn.

It was a field day for these top-level engineers as they inspected old engines, antique cars, and century-old farm equipment and machine tools. They looked under hoods, tried to figure out how some of the machines worked, and asked Curator Frank White dozens of questions. Some of the old cars brought back pleasant memories and remarks such as: "That Model T was the first car I ever drove. Quite a buggy."

Shown above are the Board members who visited the Museum. They are grouped around Chairman Kohr, in the driver's seat of the famous racer "Old 999," built by Henry Ford and driven to fame by Barney Oldfield.

Board members are (left to right): C. L. Sadler, Trevor Davidson, D. D. Streid, E. F. Norelius, Chairman Kohr, A. E. W. Johnson, Harold Nutt, O. A. Brouer, Harold Fisher (chairman of the SAE Screw Threads Committee, not a Board member), and C. F. Arnold.

Aero Materials Specs Reviewed by Industry

DRAFTS of twenty-one SAE Aeronautical Materials Specifications are currently being circulated to industry for comment and criticism by the SAE Aeronautical Materials Specifications Division.

- AMS 3243—Synthetic Rubber, Flame Resistant (55-65);
- AMS 3244—Synthetic Rubber, Flame Resistant (65-75);
- AMS 3605D—Plastic Sheet, Post-Forming, Cotton Fabric Reinforced Phenol-Formaldehyde;
- AMS 40AA—Aluminum Sheet-Laminated, Edge Bonded;
- AMS 40AB—Aluminum Sheet-Laminated, Surface Bonded;
- AMS 4040E—Aluminum Alloy Sheet and Plate, Aluminum Covered, 4.5Cu-1.5Mg-0.6Mn (Alc 2024-0);
- AMS 4041E—Aluminum Alloy Sheet, Aluminum Covered, 4.5Cu-1.5Mg-0.6Mn (Alc 2024-T3);
- AMS 4042E—Aluminum Alloy Sheet, Aluminum Covered, 4.5Cu-1.5Mg-0.6Mn (Alc 2024-T36);
- AMS 4048C—Aluminum Alloy Sheet and Plate, Aluminum Alloy Clad, 5.6Zn-2.5Mg-1.6Cu-0.25Cr (Alc 7075S-0);
- AMS 4049C—Aluminum Alloy Sheet and Plate, Aluminum Alloy Clad, 5.6Zn-2.5Mg-1.6Cu-0.25Cr (Alc 7075S-T6);
- AMS 49AB — Titanium Alloy, 5Al-2.5Sn, Annealed—110,000 Psi Yield;
- AMS 53AD — Alloy Iron Castings, Nodular, 22Ni;
- AMS —— Potting and Casting Resin—Filled—Epoxy;
- AMS —— Potting and Casting Resin—Filled—Epoxy;
- AMS —— Potting and Casting Resin—Unfilled—Epoxy;
- AMS —— Alloy, Sintered, High Density, Tungsten Base;
- AMS —— Asbestos, Polytetrafluoroethylene Impregnated;
- AMS —— Adhesive Compound—Epoxy;
- AMS —— Casting and Potting Compound—Epoxy;
- AMS —— Potting and Casting Compound—Filled—Epoxy;
- AMS —— Potting and Casting Compound—Filled—Epoxy.

You'll be interested to know . . .

. . . J. H. Kindelberger, chairman of the board of North American Aviation, Inc., served as SAE representative at the 75th birthday celebration of Dr. Theodore von Karman, held as part of IAS Summer Meeting dinner on June 20 in Los Angeles. As a tribute, Cal-Tech is making available Dr. von Karman's collected works in a set of four volumes, each of about 500 pages, including all of Dr. von Karman's papers except those already published in book form. Orders can be placed through the Publication Committee, Collected Works of Theodore von Karman, California Institute of Technology, Pasadena, Calif.

SECTIONS

JULY 1956

Reporting Section Officers' June 6 Get-Together Luncheon

Development, collection, and exchange of technical information are prime reasons for Section existence, **SAE President George A. Delaney** told some 45 representatives of 15 Sections attending the traditional Section Officers' Get-Together Luncheon on Wednesday of Summer Meeting Week in Atlantic City. These functions are most effectively performed, he added, when they result from widespread member participation. President Delaney was introduced by **Sections Committee Chairman E. N. Cole,** who presided.

When called upon, **SAE Secretary and General Manager John A. C. Warner,** strongly endorsed Delaney's comments—and congratulated the Sections upon their progress during the past year.

New Membership Record

Membership Chairman R. S. Frank reported that the Society had just set an all-time record for applications received during a Section year, with 2678 applications recorded for the twelve months ending May 30, topping by 22 the previous record established three years ago.

Journal Aid to Sections

The SAE Journal has opened its pages to Sections for exchange of ideas on making Section activities click, **Editor Norman G. Shidle** told the group. Shidle urged all Section officers and committee chairmen to follow the Sections news pages for ideas on how to do their jobs better . . . and also to work with their SAE Journal Field Editors in getting into Journal print programs which are working out most successfully in their Sections.

Use of SAE Journal pages as a medium for exchange of ideas on Section operation started in November 1955, and is just now getting fully underway. It can be most successful, he added, if each Section names a strong Field Editor and if every Governing Board member works with the Field Editor in getting the Section's strongest points into print, available for others to adapt to their Sections.

Suggestions Requested for Revision of SAE Section Procedure

A good start has been made on the revision of SAE Section Procedure, reported **W. F. Ford,** a member of the subcommittee of the Sections Committee Executive Committee assigned to that job. He noted the subcommittee has not felt that a major revision is necessary. Two recommendations are being offered for policy revision, he added. One is to establish a definite quorum for Governing Board meetings. The other is to require that a minimum of four Governing Board meetings be held each year. Ford urged that suggestions for revisions in Section Procedure be sent to **T. R. Thoren,** chairman of the subcommittee, with copies to Headquarters.

Cole then called for general exchange of ideas on Section activities.

Finance Committee Keeps Tabs

A three-man Finance Committee drafts the Northern California Section budget and insists that the Governing Board stick to the budget once it has been adopted, **Northern California Section Past-Chairman W. G. Nostrand** told the group. The Governing Board appoints the Finance Committee, but it is prescribed that the committee shall be chairmanned by the current Section vice-chairman; that one member shall be a past-chairman of the Section; and, that the third member shall be a member of the Section who is not a past-chairman. The third member, Nostrand said, is one of the Section's "elder statesmen". The current treasurer is an ex-officio member of the committee.

Ideas for Social Functions

Charles Chambliss, 1956–1957 chairman of the Metropolitan Section, reviewed some of the Section's past social events, including those held at golf clubs, aboard an ocean liner (in port) and at city clubs. Important ingredients are good food, dancing, and some stunt in which the members participate. This year's event is planned as a cruise on the Hudson, featuring a moonlight sail, a top-notch buffet, and dancing to a fine orchestra, he said.

Carrier Trips

San Diego Section Past-Chairman W. C. Heath told of arrangements the Section had made with the Navy for a cruise on an aircraft carrier. He explained that the Navy welcomes groups such as SAE Sections aboard aircraft carriers and other ships. Discussion revealed that the New England Section also had arranged such a cruise. Nostrand announced that an all-day carrier cruise is to be one of the highlights of the SAE National West Coast Meeting to be held in San Francisco, August 6–8, 1956.

DETROIT

W. F. Sherman, Field Editor

The final event of the 1955-1956 season for the Junior Group was concluded on the afternoon of April 24, when the group toured the new Plymouth V-8 Engine Plant.

Among the highlights of the tour was the predominance of automation used in this plant from crankshaft machining to final engine dynamometer testing.

It was interesting to find that to produce the 150 engines per hour that this plant is geared to produce, it took over 47 underground and overhead conveyors, 20,500 miles of wiring, and a floor area of 534,059 square feet.

Prominent Detroit Section Members at Technical Center SAE Day

DETROIT

W. F. Sherman, Field Editor

A 330-acre area housing 25 buildings for more than 4000 engineers, researchers, designers, mechanics, machinists, and other specialists—the brand new GM Technical Center—was opened to detailed inspection by 2400 Detroit Section members and guests on May 17. The big event, including a general tour of the grounds, dinner, and the Detroit Section May technical meeting, was known as SAE Day at the Center.

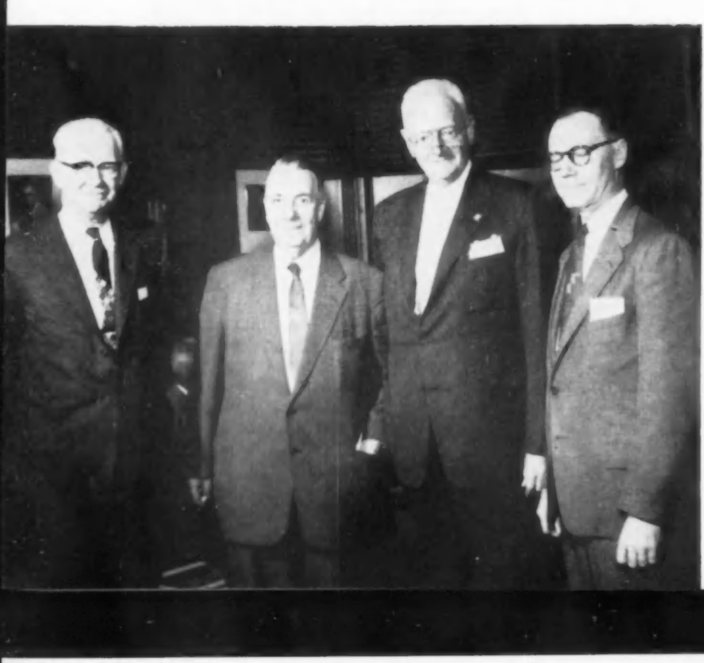
Toastmaster for the occasion was **L. C. Goad**, General Motors executive vice-president and a past SAE vice-president for Production Activity. Detroit Section Chairman **K. R. Herman** served as general chairman.

Special thanks went to General Motors Corp. for the preview in a talk by 1956 SAE President **George A. Delaney**. Said SAE's chief officer, "This great technical center graphically illustrates the tremendous increase in technical talent required by today's industry.

"The only useful product of all this array of facilities and people is ideas. And the production of ideas in this rapidly changing world is measured by the degree of contact with the constantly shifting sources of scientific endeavor.

"It was out of this realization that the Society of Automotive Engineers was born. As expressed in its constitution, the purpose of this Society is to develop, collect, and distribute technical information—by and for its members—in their areas of technical interest.

"It is true that significant developments which result in progress are born



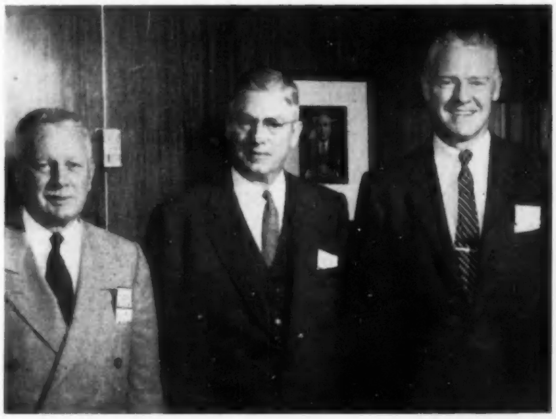
(Left to right) Detroit Section Chairman K. R. Herman Vickers Corp.; John A. C. Warner, SAE secretary and general manager; Charles A. Chayne, GM vice-president in charge of engineering staff, who was the chief speaker; and Dr. Lawrence R. Hafstad, GM vice-president in charge of research staff.

in some man's mind. But that mind must be intimately acquainted with the present state of the art and the scientific fields which apply. It is in this area of collecting and distributing basic technical information which, in turn, stimulates ideas, that the SAE renders its service to both its members and our great industry."

Featured speaker for the ceremonies was **Charles A. Chayne**, vice-president in charge of engineering staff, General Motors Corp. His description of the Center and its purposes included the following statement:

"The GM Technical Center is a tribute to creative individuals wherever they may work. It is dedicated to an advanced type of research and development. Many valuable projects have already been completed here. Important as any discovery may have been, however, there is still something greater which places like the Technical Center tend to assure. That greater thing is the freedom and the means to make even more important discoveries."

SAE Day Toastmaster at GM Technical Center was L. C. Goad (right), GM executive vice-president and a past SAE vice-president for Production Activity. SAE Past-President James C. Zeder (center), is vice-president of engineering, Chrysler Corp.; Rodger J. Emmert (left), executive in charge of facilities and processes staff, GM Manufacturing Staff, is also a past SAE vice-president for Production Activity.



SAE President George A. Delaney (center), chief engineer, Pontiac Motor Division, spoke for the Society at the Detroit Section Meeting at GM Technical Center. At left is M. F. Moore, vice-president of engineering, American Motors Corp. At right is Charles Dybvig, Dana Corp., chairman-elect of the Detroit Section.

Left to right are three honored guests at SAE Day, May 17: E. H. Kelley, SAE vice-president for Production Activity and Chevrolet general manufacturing manager; James M. Crawford, 1945 SAE president; and Charles L. McCuen, former GM vice-president in charge of research staff.

Two GM officials stand company with three more honored guests at the festivities. Left to right are: George R. Squibb, of GM process development section; C. W. Ohly, Detroit Section vice-chairman for Production Activity and vice-president and general manager of Thompson Products, Michigan Division; R. F. Kohr, SAE Technical Board chairman and director of general engineering, Ford Engineering Staff; S. W. Taylor, vice-president of engineering, Willys Motors; and Glen R. Fitzgerald, director, GM process development section.

From Section Cameras

No. California

L. J. Abell, Field Editor

Northern California Section held its last meeting of the 1955-1956 year on May 23, Past-Chairmen and Old Timers' Night. Principal guest was **Dr. C. G. A. Rosen**, 1955 SAE president, who gave a short talk on the "Engineering Future."

Clessie L. Cummins, chairman of the board of Cummins Engine Co., Inc., received a 35-Year Membership Certi-

1. A number of the honored guests at Northern California Section's Past Chairmen and Old Timers' Night May 23 gathered for this Journal photograph.

Standing left to right are William G. Nostrand, 1951–1952 Section chairman; John A. Edgar, 1953–1954 Section chairman; Fred W. Twining, 1942–1943 chairman; R. Wayne Goodale, 1947–1948 chairman; Alfred G. Cattaneo, 1943–1944 chairman; Roy A. Hundley, 1955–1956 South Bay Division chairman and 1948–1949 Section chairman; Warren G. Brown, 1955–1956 chairman; and S. E. Onorato, 1944–1945 chairman.

Sitting left to right are Charles F. Becker, 1941–1942 chairman; John M. Evans, 25-year member and 1933–1934 chairman; George L. Neely, 1938–1939 chairman; John R. MacGregor, 1954–1955 chairman; Charles A. Winslow, 1946–1947 chairman; Alfred Marshall, 1936–1937 chairman; and Edward J. McLaughlin, 1950–1951 chairman.

2. Guest speaker at the May 8 meeting of Northern California Section's South Bay Division was R. A. Wagner (center), chief engineer, Hiller Helicopters, Inc. At right is R. A. Hundley, South Bay Division chairman. Program chairman for the evening was W. A. Casler (left).

3. A field trip through the Hiller Helicopter plant preceded the Northern California Section South Bay Division May 8 meeting. Members and guests were intrigued by the Hiller ram jet powered rotary wing aircraft called the Hiller Hornet.

ficate. A 25-Year Certificate was given to **John M. Evans**, partner in Evanstrom Co.

The Section was happy to welcome 17 of its 19 past-chairmen to this last meeting of the year.

No. California Section

South Bay Division

Enthusiasm was not dampened by rain in Palo Alto, May 8. South Bay Division members numbering 150 were present for a tour of the Hiller Helicopters, Inc., plant. A flight demonstration of the Hiller H-12-C commercial (H-23-C military) helicopter and inspection of the production facilities, engineering offices, and experimental hangar were featured.

Williamsport

C. F. Pannebaker, Field Editor

Penn State University Student Branch visited Cornell Aeronautical Laboratory, Inc. in Buffalo, N. Y., recently for a day-long tour of facilities and discussions with engineers on the research and development programs of the Laboratory.

From Section Cameras

4. Paul G. Osborn (center), factory manager at Convair's Plant 2 in San Diego, gives a close-up look at Convair's F-102A supersonic all-weather jet interceptor to Robert G. Sharp (left), San Diego Section chairman and Philip M. Klauber, Section Meetings chairman, at the April 10 meeting.

5. Penn State University Student Branch members get a run-down of aeroelastic research performed in the Aero-Mechanics Department of Cornell Aeronautical Laboratory, Inc. on April 20.

6. Pausing along the way to inspect a CAT DW20 on the Central Illinois Section tour of Caterpillar's Decatur plant are: (above left) Charles Brown; (above right) Andrew Johnson, Central Illinois Section vice-chairman for Decatur; (below left) Harold Johnson, staff engineer, Caterpillar Tractor Co.; and (below right) Paul Benner, chief engineer, Decatur Engineering Department, Caterpillar Tractor Co.

Following their election on May 21, several of the new St. Louis Section officers pose with Immediate Past-Chairman Clifford R. Feiler and 1956–1957 Chairman Henry Buelt during the Gavel Exchange ceremony. Left to right are Robert Lemen, 1956–1957 vice-chairman, Transportation and Maintenance; Clifford Feiler; Henry J. Buelt; Alfred Stoehr, 1956–1957 vice-chairman, Fuels and Lubricants; and Gene Kropf, 1956–1957 vice-chairman.

ST. LOUIS

F. H. Roever, Field Editor

The traditional gavel exchange ceremony was a highlight of the St. Louis Section May 21 meeting at Parks College of Aeronautical Technology. Section 1956-1957 officers are shown above with immediate Past-Chairman **Clifford R. Feiler.**

Parks College Student Branch and the Student Branch from Missouri School of Mines and Metallurgy had a surprise in store for **Albert Hazell,** president of Hazell Machine Co. He has for several years paid one-half of all students meals at the Section meetings. In gratitude, the two Student Branch Chairmen, **Robert Beelman,** Parks College, and **Roger Berkbigler, MSM,** presented Hazell two sets of mugs with official college crests—three from Parks and three from MSM.

Presenting sets of mugs with official college crests to Albert Hazell, president of Hazell Machine Co., for contributing one-half of all student meals at Section meetings, are Robert Beelman (left), chairman of Parks College Student Branch, and Roger Berkbigler (right), chairman of the Student Branch at Missouri School of Mines and Metallurgy.

So. New England

S. L. Leavitt, Field Editor

Yale University Student Branch increased its membership 35% during 1955-1956. It also initiated two new activities into the program schedule, the Film Series and the Annual Outing. Branch members have been showing movies occasionally on weekday nights to the college population. Some of the most successful showings were: *Home at the Wheel,* General Motors Library; *Air Power on Parade,* Bendix Aviation; *The Torque Converter Story,* Allis Chalmers; *Aeroelasticity,* Lockheed Aircraft; and *This is Automation,* General Electric.

The Annual Outing, sponsored jointly by the SAE and ASME Student Branches, was celebrated on Sunday, May 6, at the Yale Engineering Camp, Old Lime, Conn.

Central Illinois

Harlan Banister, Field Editor

Caterpillar Tractor Co. was host to 200 members of Central Illinois Section April 30 at the new plant in Decatur, Ill.

After dinner the 200 were divided into groups of seven. With members of the Decatur Engineering Department as guides, a tour of the manufacturing department and assembly lines was made. The Decatur plant manufacturers wheel-type tractors and motor graders.

SAN DIEGO

R. E. Day, Field Editor

On Tuesday evening, April 10, the San Diego Section—limited to 90 members and student branch members for security reasons—were guests at Convair-San Diego Plant No. 2 where the F-102 Interceptor is in production.

Paul G. Osborn, factory manager, summarized Plant No. 2's activities from raw material to flyaway and U. S. Air Force acceptance at Palmdale, Calif. He later headed an 11-man Convair team of guides in taking mem-

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Sections

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bers on a one and one-half hour tour.
Members were given a close-up view of the F-102 that is tremendous in both physical size and in importance to the country.

PITTSBURGH

W. C. Weltman, Jr., Field Editor

H. O. Creazzi (left), Pittsburgh Section chairman, chats with guest speaker Mauri Rose during the Section May 16 meeting.

Annual Spring Outing was celebrated May 16 at both Wenango Country Club and Franklin Club. Golf was the center of attention at Wenango. For non-golfers, there was a tour of an oil refinery. Center of attention at the dinner meeting at Franklin Club was Mauri Rose, three-time winner of the Indianapolis 500 sweepstakes. His subject was "Stock Car Racing."

ALBERTA

William Fairhead, Field Editor

THE Group wound up its 1955–1956 Section year with a successful Ladies Night party on May 18 in the Al San Club's Mural Room. Acting Mayor Clarence Mack of Calgary spoke following the dinner which was a feature of the occasion. Mayor Mack sketched the aims of the Society of Automotive Engineers and emphasized how much it means to Calgary to have an SAE Group headquarters here. A floor show followed the installation of officers for the 1956–1957 Section year. Chairman for the coming year is Frederick G. Forster; vice-chairman, John G.

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Sections

Continued from page 95

Bruce; treasurer, Henry J. Rasmussen; secretary, Francis Rice.

CANADIAN

F. G. King, Field Editor

THE Section's Oshawa meeting was held May 26th this year. More than 275 members and guests attended the 1956 version of this annual Section event.

Seventy golfers took part in the golf tournament which is a feature of the day. GM of Canada was host at the reception which preceded the dinner and E. F. Armstrong, GM of Canada's chief engineer, was chairman for the meeting.

The speaker was Russell E. Kaufman of Chevrolet, who came from Detroit to tell the Canadian engineers about Chevrolet's new "powermatic" automatic transmission for heavy-duty trucks.

Some of the head table guests at the

meeting included the men pictured above: From left to right they are: Harold C. Brindle, Auto Electric Co.; Neil P. Petersen, Canadian Acme Screw & Gear; William A. Wecker, General Motors of Canada; Russell E. Kaufman, Chevrolet Division, GM Corp., Detroit; A. W. Hopton, SAE Canadian Section chairman, Dominion Rubber;

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Sections

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R. S. McLaughlin, chairman of the board, GM of Canada and an SAE member since 1909; E. F. Armstrong, GM of Canada; and James C. Armer, Dominion Forge & Stampings.

INDIANA

V. L. Alexander, Field Editor

NOTABLES associated with the 500-mile Indianapolis Race from its inception in 1911 until now were among those present at the May 17 Section meeting. Below are the special tables reserved at this meeting for past chairmen of the Indiana Section. They were out in force. 1955-56 Section chairman, who presided at the meeting, is Carson O. Donley.

MILWAUKEE

J. W. Mohr, Field Editor

SECTION members toured the Kearney & Trecker Special Machinery Plant on May 4. A plant tour has become an annual feature of the Milwaukee Section program.

The Kearney & Trecker tour started at 1:30 pm and lasted about two hours. Members of the Section had an opportunity to observe the manufacture and assembly of special machine tools for production industries. All types of automatic production machines are designed and built to customer specifications in this new factory. Approximately 300 persons attended the tour.

The regular May meeting was held following the plant trip, at the Tucka-

CONTINUED ON PAGE 100

Morse Automotive Timing Chain —built with fine-watch precision

Precision manufacture is your guarantee that Morse Timing Chain—like a fine watch—will give years of dependable, trouble-free service.

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*trademark

Sections

Continued from page 98

way Country Club. In the interim, between the completion of the tour and the start of the meeting, movies were shown covering the design and operation of some of the special machine tools designed and manufactured by Kearney and Trecker.

The main speaker of the evening was John Bunce, assistant works manager for the Kearney and Trecker Corp. His paper was "Planning and Operation for Special Machinery Production". The picture below shows some of the Milwaukee Section members inspecting a sample of the work turned out at the special machinery plant.

The annual plant tour winds up the formal aspect of the Milwaukee Section's meetings for the season. The main social event is the Ladies' Night Party, which takes place in June.

New England

George T. Brown, Field Editor

Dr. Richard Kloss (left), director of engineering, Klockner - Humboldt - Deutz, Cologne, Germany, traveled from Germany to speak at the New England Section March meeting. He is presented a certificate of appreciation here by Section Chairman J. Roy Smith.

Record attendance marked the March meeting as 203 members and guests were present to hear Dr. Richard Kloss, director of engineering of Klockner-Humboldt-Deutz, Cologne, Germany, deliver his paper on High Speed Air-Cooled Diesel Engines.

Guests at this meeting included representatives from the U. S. Army, Navy, and Air Force, as well as a number of members from other Sections.

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SPECIALISTS IN AIRCRAFT LANDING GEAR

Complexity Bugaboo Of Military Aircraft

Based on paper by

A. F. MATTHEWS

McDonnell Aircraft Corp.

TO appreciate how complexity is threatening the reliability of military aircraft one has only to review the fuel system and realize that it is only one major system. Other systems are equally or even more complex.

Let us consider a typical fuel system:

There are three main fuselage tanks, of which two are bladders and one is of the self-sealing type. We can place three bladders in each wing root, two in each wing leading edge, and two integral tanks in each wing outer panel. We will hang one external tank on each wing and we can have the option of one on the centerline store rack. This gives us 20 tanks total in which we can pack 3550 gal of fuel.

We have the three fuselage tanks with the various filling provisions and the piping to the engines. Note there are four ways to fill: gravity, single point ground, boom-type inflight refueling (IFR), and probe-type IFR. All of the pressure filling methods feed into a common manifold which serves also as a transfer manifold; the transfer pumps, the wing, and the external systems all feed into this manifold as well. Even the straightforward supply system to the engines must be cluttered up with such things as oil coolers, so that the fuel can be used to cool other things, plus the filters and shut-off valves.

The wing system relies on air pressure to transfer the fuel because the wing is too shallow for pumps. This is in the direction of simplicity, so the hypothetical airplane is not altogether bad.

Here the fuel system is reversible. Fuel must flow in either direction so that we can fuel and defuel through the same lines. We have an empty indicator to shut off the system when empty, as well as signal the pilot. We have a flow limiter to prevent filling too fast since we can have 60 psi putting fuel in and we don't want to blow up the wings. We have a shut off valve, controlled by the float switch which also gives a full indication. We use pressurized air from our engines which must be pressure regulated, and cooled, before entering the tanks and we must have a vent valve to permit the escape of air while fueling as well as to provide pressure or vacuum relief as required.

The three external tanks are hooked into our system in a manner similar to the wing tanks. They must have individual controls for pressure filling and flight refilling since each must shut off as it fills. They too use air pressure for transfer.

The wings and external tanks have individual vents, but the fuselage requires special treatment. Here we want to pressurize in order to help our pump performance at altitude and to prevent loss of fuel from boil-off at altitude. Therefore, normally our vent is closed and pressure is on; but to prevent hazards in combat, we vent to the atmosphere when in combat. At that time, we modulate flow from the ram strut to keep the pressure close to ambient.

Our fuselage tanks need protection against enemy gunfire so we use an electronic triggering device which explodes cartridges, if a fuel explosion starts, and douses an explosion before it begins.

As our wings become empty, we have virtual bombs on each side due to fuel vapors in the tanks, so we will make them inert by bleeding in nitrogen or carbon dioxide.

We must gage this fuel to help the pilot. Therefore, let us use four probes in the fuselage and three in each wing. We could put one in each wing tank,

but I am trying to stick to fairly logical solutions which we know would be used. This gives us accurate gaging of fuselage fuel and a sort of step indication of wing fuel. That is, during use of wing tanks, the pilot knows that if we let x, y, and z represent different quantity stages at which we pick up signals, he has less than x and more than y or less than y and more than z at any specific time.

We will not gage the external fuel because it is impractical, but we know the tanks are full or somewhere between full and empty or that they are empty, and we throw them away.

Now let's see what it adds up to. The pilot has five basic selections of fuel usage he can make and two flight refueling choices. They are: off or (1) gravity flow of fuselage system, (2) external wings, (3) external centerline, (4) wings, (5) fuselage pumps, and boom IFR and drogue IFR.

This doesn't sound too bad, but see what is behind the scenes. There are 23 combinations of conditions that must be sensed by some means in order that the right things happen and so that we don't dump fuel overboard or pump from wings to external tanks.

You can see the complexity that is built into this machine. Just think of the switches, relays, and wiring required to make this system work; and remember, this is only one major system of this airplane.

There are at least 107 components involved, not including any switches or relays, but it will also take some 400 fluid connections. These are potential leaks and some are frequently disconnected, adding to their unreliability. This system needs about 15 relays and 17 switches and seven black boxes to keep control. How reliable is it?

Let's be generous and give our components an average reliability of 99%. We have 107, so our over-all reliability is 99 multiplied by itself 106 times or about 35%. Let's say our couplings are 99.5% reliable and we have 400, so our odds are nine to one we would have a leak. Fortunately our leak reliability is better, but even if it is 99.8% per unit we still have a 50-50 chance of a leak.

We could go over each system in this airplane in detail such as we have here and you would find some even more complex than this. I am sure you agree something needs to be done about it.

What shall we do about all this? The answer is obvious—simplify. How? The first big step will be to drop the "work horse" or "over-all utility" concept and design our airplane for a specific job.

What is this job? Here is one example: An object is coming from an enemy country, aimed at us. Our job is to shoot it down a safe distance away. What does it take? It takes:

A Missile—to blow up the target—in this case we'll use an air-to-air, homing type.

A Man—to eliminate complexity and carry out the job.

An Airframe—to carry man and missile to the target area.

An Engine—to propel airframe.

Fuel—to run engine.

One radar—to seek target.

One radio—to guide us to target and back by the use of ground assistance.

We will leave everything on the ground that does not contribute to the accomplishment of this specific mission. No starters, no batteries, no landing gear—we will take off from a carriage and land on skids,—no extra radars nor radios, no boundary layer controls, no autopilot. And we won't design for fantastic maneuvers at high speeds, not perfect a yaw and roll stabilizer because all we must do is get within range, and if pointed in the right direction, we release our missile and then pull away.

This then can be a simple, straightforward, small clean airplane. It will be more reliable by simple mathematics. Because of its simplicity, it is cheaper to build and maintain, and we can build more of them.

(This report is by Field Editor Fred H. Roever. Paper "Complexities of

Aircraft—Primarily Combat Aircraft" was presented at SAE St. Louis Section Meeting, Oct. 17, 1955. It is available in full in multilith form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)

Elastomers Enhance Rubber Flooring Mats

Based on paper by

J. F. McWHORTER

The Ohio Rubber Co

THE durability, conformability, flexibility, and insulating property which recommend low cost rubber compounds for floor covering are enhanced by giving the rubber long wearing, colorful and easily cleaned elastomeric coatings. The coatings retard reduction in gage from heel abrasion, their high film strength increases tear resistance, and many of them are highly resistant to oxidation so that the sub-stratum compound is protected and the quality of the rubber appreciably preserved.

Valley printing, lithographic printing, and embossing may be used to decorate the vinyl surfaces and the application of the veneers to the rubber sheets gives a product that simulates textiles.

The status of automotive floor covering is never static and interior styling is now directed toward incorporating the esthetic, kinesthetic, and noise absorption values of textiles with the values of easy forming, resistance to wear, and low cost to be found in elastomeric materials.

(Paper "Decorative Elastomeric Floor Covering for Automobiles" was presented at SAE Car Body & Materials Meeting, Detroit, March 6, 1956. It is available in full in multilith form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)

Turbulent Jet Noise Undergoes Basic Study

Based on paper by

NEWELL D. SANDERS

and

JAMES C. LAURENCE

National Advisory Committee for Aeronautics
Lewis Flight Propulsion Laboratory

IN a fundamental investigation of noise generated by turbulent jets, Lighthill's suggestion, that the actual

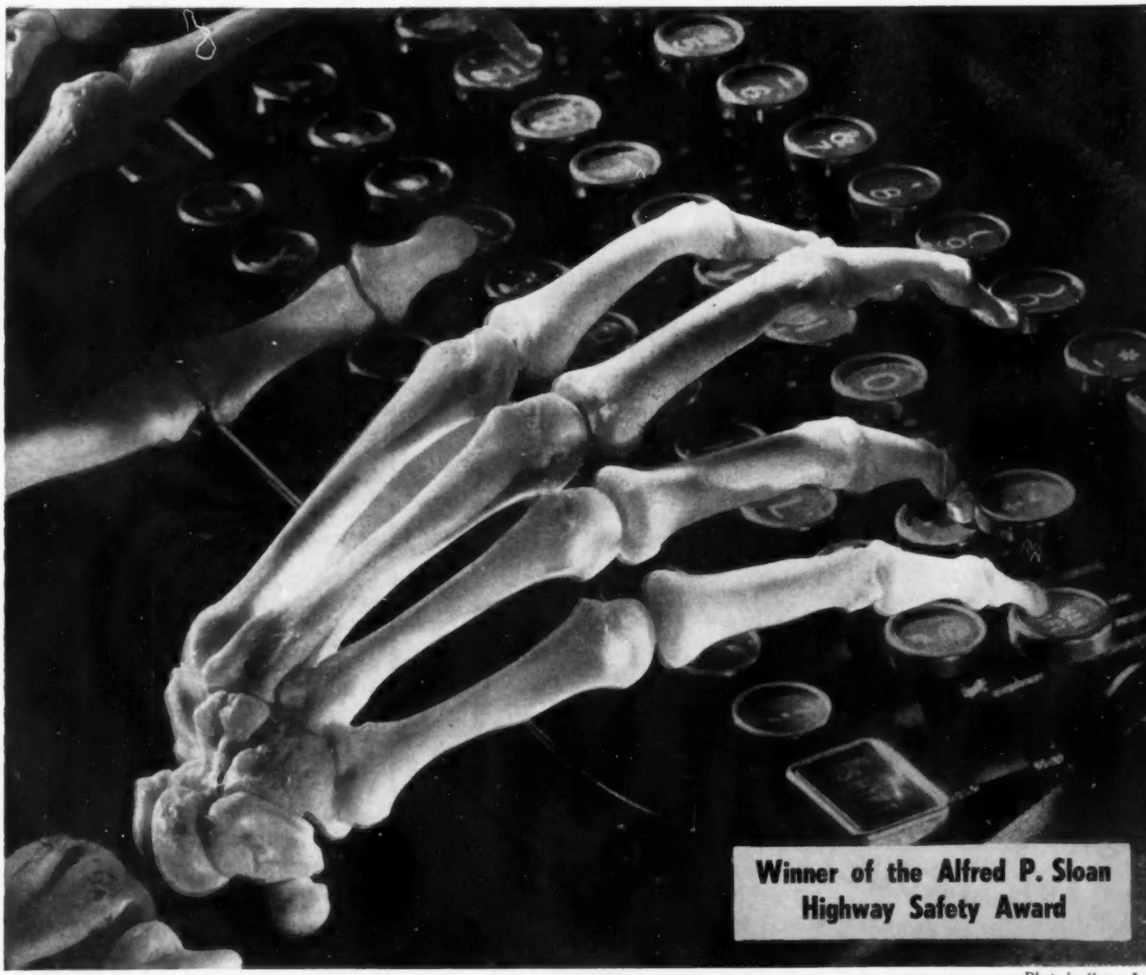

Photo by Sarra Inc.

I am a typewriter. Across my ink-stained face are written many human experiences. During the coming beautiful days, I shall pound into the record books many names.

I SHALL WRITE—Killed, passing on a hill, John Doe.—Killed, passing on a curve, Bill Doe, wife and 3 children.

I SHALL ALSO WRITE—"To save a minute, he lost a life" or "A minute saved—a quick trip to the grave."

Tired, hackneyed phrases describing the end of bubbling, enthusiastic, happy lives.

I write on...pounding names into the record books of death.

What's YOUR name? What's YOUR WIFE'S name? How many CHILDREN have you?

Because so many answer, I must write—I must work. YOU can make every day safer for yourself and your family by driving EXTRA carefully. Please be courteous, be careful—I CAN SPELL ANY NAME.

Automobile manufacturers and automotive suppliers are continually improving cars to help reduce the accident-causing tensions of driving. One of these suppliers, Auto Specialties Mfg. Co., Inc. of Saint Joseph, Michigan, has developed safer brakes for today's more powerful cars: Auto Specialties Double-Disc Brakes. These brakes, designed on an entirely new principle, have passed severe braking tests at leading car factories. Auto Specialties Double-Disc Brakes make driving safer, make drivers surer of their brakes. Their adoption by the car factories will be in keeping with the automotive industries' aim for safer and safer driving. So while you're out driving, be courteous, be careful. Remember, "I CAN SPELL ANY NAME."

A 16-page, 4-color book, "The Stopping Story," gives detailed information about these brakes. It's free. Write for it to

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flow field be simulated with a stationary field of quadrupoles, was used to obtain equations relating the noise outside of a turbulent jet to the turbulent velocities inside the jet. Hot wire anemometer techniques were then applied to a $3\frac{1}{2}$ in. air jet to measure the turbulent structure of the mixing region. The equations and measurements thus obtained were used to estimate some of the characteristics of the sound field, with results that were found to be in good agreement with the experimentally measured sound field of a full-scale turbojet engine.

An analysis indicates that the total sound power radiated from the jet should vary as the eighth power of the jet velocity and the cross-sectional area of the jet. It also has predicated successfully many of the important characteristics of the near field and the variation of the total sound power with nozzle size and jet velocities in the far field. The analysis is being continued particularly with respect to the light it may shed upon noise reduction. (Paper "Fundamental Investigation of Noise Generation by Turbulent Jets" was presented at SAE National Aeronautic Meeting, New York, April 11, 1956. It is available in full in multilith form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)

Aluminum's Future in The Automotive Industry

Based on paper by

LEO F. SWOBODA

Kaiser Aluminum and Chemical Corp.

ALUMINUM's properties, availability, and lower finished part cost are responsible for its increased use in automobiles. Even greater use of aluminum is expected in the automobiles of the future.

Aluminum's unique combination of properties will be responsible for many of its applications to cars of the future.

One of the future applications depending on the right combination of properties is brake drums. Here the high thermal conductivity of aluminum makes it particularly useful because of its ability to absorb rapidly, and subsequently dissipate, the large amount of heat generated during braking.

The low density of aluminum is also advantageous because it reduces unsprung weight, thereby improving the riding characteristics of the vehicle. Preliminary studies and investigations on the use of aluminum for wheels and brake drums, either as separate or integral units, show considerable promise, but more development work is needed before these will be available for general use.

Another future aluminum application is the cylinder block. Here aluminum's low density and high thermal conductivity are advantageous. By using aluminum it is possible to save as much as 100 lb of dead weight. Such a weight saving would result in improved performance and economy and better and more equal weight distribution between front and rear axles. The high thermal conductivity of aluminum would improve operating conditions and increase efficiency by providing more uniform temperatures throughout the block.

More aluminum exterior trim parts will be used on the automobiles of the future. The pleasing appearance, good corrosion resistance, light weight, and durability of polished and anodized aluminum will be responsible for its increased use.

A fairly safe prediction is that aluminum radiator grilles will soon make their appearance on a number of cars. A natural bright finish will be used for this application.

A further prediction is that aluminum bumpers and hub caps will be the next bright finished aluminum items to appear. Aluminum is well suited for these parts, and they can be finished to match the grille.

The aluminum grille can be made as a stamping or casting, or be built up from extrusions in an unlimited variety of designs. Besides the advantage of distinctive appearance, the weight saving is particularly important because it occurs at the front end, which in most cars is too heavy for best weight distribution.

The availability of aluminum in all its forms at a relatively stable price without threat of short future supply will stimulate its use for many automotive parts. Examples of parts in this category are radiator and heater cores, electrical conductors, and some screw machine parts.

Without doubt, the aluminum radiator core is the most outstanding unit in this group, not only because of the large potential aluminum requirements, but because it did present seemingly insurmountable problems, both in service requirements and in production techniques. Fortunately, most problems have been essentially overcome through diligent research, and we are confident that aluminum radiators will be production items within a year.

To speed up the use of aluminum in radiators, development work is progressing on a hybrid type, having brass coolant passages and aluminum fins. The all-aluminum radiator is still the ultimate goal, and it appears that the new fluxes being developed will overcome the objections the automotive industry has to those presently being used.

The next most promising future aluminum use which depends on its ready availability is for electrical conductors —particularly for the field coils and armature windings used in electric motors, generators, and starters. Battery cables, ground straps, and wiring har-

ness also should be included in this group.

Aluminum applications determined on the basis of lower finished part cost are numerous. Notice that we say lower finished part costs, because it is only when all the costs are totaled that the savings become apparent in some applications. For example, the initial material cost when compared with steel is greater for aluminum, but in many cases this cost differential is soon overcome by savings resulting from the elimination of degreasing, pre-paint treating, painting, and incidental handling.

Outstanding examples of parts in this category are the headlamp retaining ring and sockets. Many are now being made of aluminum, wholly on the basis of lower finished cost, despite the fact that an incomplete cost analysis might show that savings were not possible. Other examples are valve assemblies, stators and impellers, and extensions for automatic transmissions, flywheel housings, and screw machine products.

The savings in aluminum valve bodies and covers are due chiefly to reduced cleaning and machining time. These parts have many deep, intricate passages and ports directing the flow of oil. When they are made of aluminum, much less labor is required for inspecting removing obstructions, and smoothing rough areas. Also the actual machining time is much lower for the aluminum die castings than for iron castings.

The lower finished costs of the cast aluminum stator and impeller are due largely to their lower fabricating and machining or finishing costs. It is no longer necessary to fabricate the numerous individual pieces and assemble them into a unit by welding, brazing, and riveting, with the resultant high labor costs.

The aluminum die castings are made as integral units requiring very little machining or balancing. In addition, it is claimed that the true airfoil section of the die cast vanes results in better efficiency throughout the normal operating range as compared to units using cambered sheet vanes.

Aluminum flywheel housings and automatic transmission extensions are lower in finished cost because of the low fabricating cost of the rough casting, lower machining costs, and absence of painting costs.

Screw machine parts made of aluminum show appreciable cost savings over duplicate parts made from the common copper base alloys and stainless steels. The great difference in material cost for an equal number of parts is responsible for the major savings, but additional savings are possible because of higher permissible cutting speeds and increased tool life. (Based on secretary's report of panel discussion on "Materials and Processes for Tomorrow" held at SAE Golden Anniversary Summer Meeting, Atlantic City, June 13, 1955.)

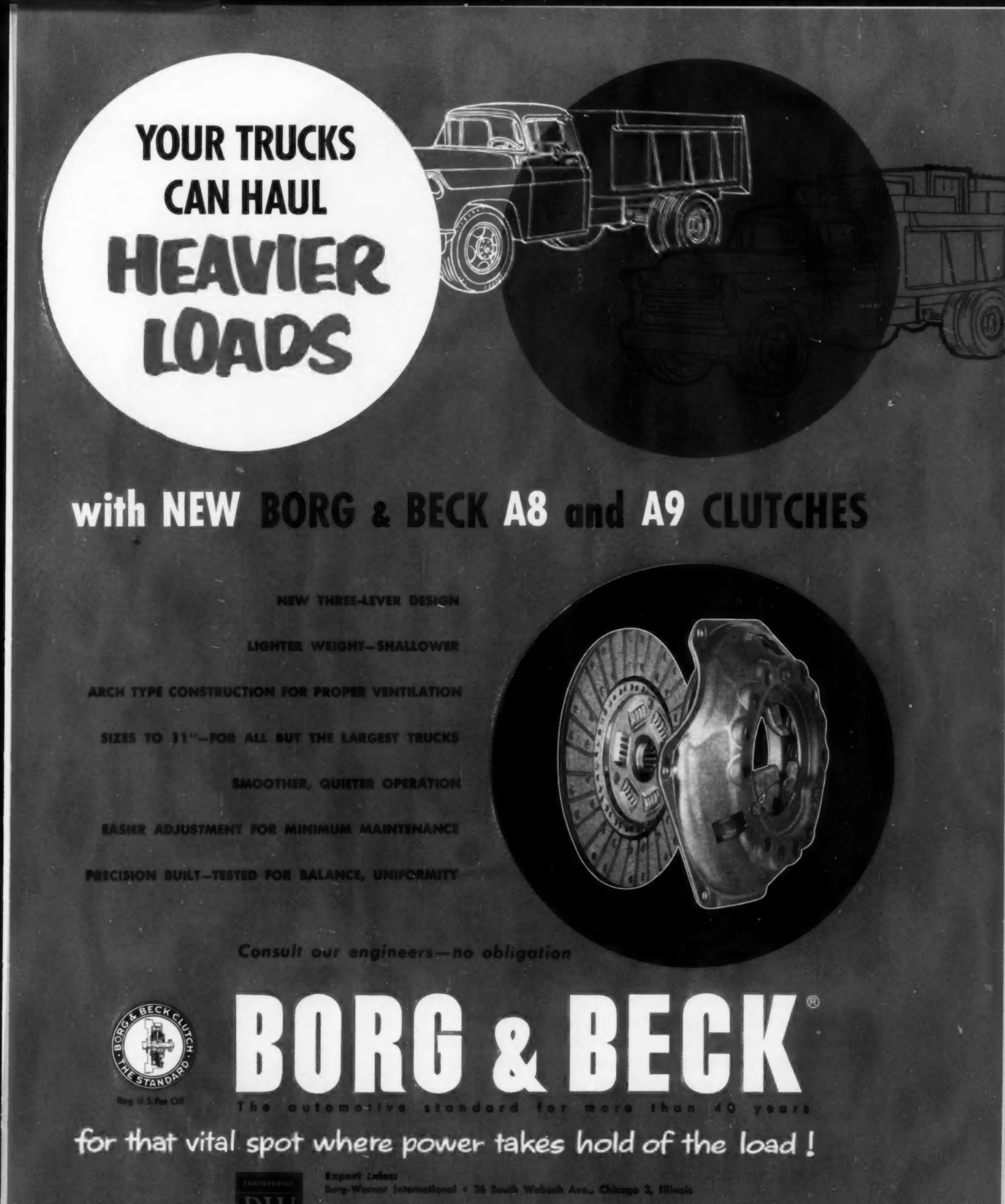
Design Advances Compel Manufacturing Research

Based on report by

W. E. GREEN

The Glenn L. Martin Co.

RAPID advance in product design makes mandatory the development of new processes and methods for the manufacture of these designs. More efficient and time-saving methods also are needed for advising the engineer how to make his design for economical production. Manufacturing re-


YOUR TRUCKS
CAN HAUL
HEAVIER
LOADS
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NEW THREE-LEVER DESIGN
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search organizations have been created to achieve these ends, and it is their job to supply information on new processes and methods.

Research is being carried on in the manufacture of forgings to find a die metal which will permit more economy in tool costs for a limited number of parts. Malleable iron types were investigated and found to be the least desirable of several die metals. Kirksite dies were used to produce a wing forging with a resultant estimated time span saving of approximately four months. Beryllium copper dies have shown the most promise to date. They reproduce very accurately from the pattern, maintain their shape well, and show negligible die wear.

Roll forging is also being pursued as a method of parts manufacture. It offers the advantage of reducing substantially the problem of chip removal with its attendant complement of skin milling machines. Etch milling represents another and very different approach. This method employs a chemical reaction for the removal of metal. The silk screen process is used to mask those areas where metal removal is not required. This method provides a good solution to the problem of deformation caused by machining.

Negotiation between engineering and manufacturing can be used to avoid the extreme of "we can make anything or we can't make anything." This philosophy is illustrated by the problem of converting a typical steel part to titanium. A compromise design was reached by negotiating what could be done economically with what was required functionally.

Sometimes a new concept of design promotes the need for manufacturing research. A new missile, designed to use honeycomb exclusively in the wing and tail surfaces, provides an example. This presented a challenge to devise a method of production which would produce an economical product. That the challenge was met is indicated by a cost reduction of 25 to 30% over the conventional structure.

Too much manufacturing research can never be done if the status of the manufacturing art is to progress. Such research must precede engineering to give more latitude for design and keep ahead of production problems.

Panel on Economics of Tooling which developed the information in this article consisted of:

Panel Leader:

G. A. Evans
The Glenn L. Martin Co.

Panel Co-Leader:

N. H. Lou
Republic Aviation Corp.

Secretary:

W. E. Green, Jr.
The Glenn L. Martin Co.

Members:

D. G. Gilmore
Chance Vought Aircraft, Inc.

R. L. Grunewald
General Electric Co.

A. S. Hartwig
McDonnell Aircraft Corp.

W. Krug
Lockheed Aircraft Corp.

G. W. Periman
North American Aviation, Inc.

The panel discussion was part of the SAE Aircraft Production Forum, held in Los Angeles, Oct. 5, 1954.

New Members Qualified

These applicants qualified for admission to the Society between May 10, 1956 and June 10, 1956. Grades of membership are: (M) Member; (A) Associate; (J) Junior.

Alberta Group

Morris, W. Tees (M).

Atlanta Section

Thomas P. Garden (A), George T. Hicks (A), Thomas A. Reed (A), Albert C. Ruehmann, Jr. (A), Charles C. Smith (M).

Baltimore Section

David Morgan Hall (A), Terry T. Hall (A), C. H. Smith (M).

British Columbia Section

Willis W. Brookman (A), Bernard Clarke (A).

Buffalo Section

Wendell D. Holcomb (A), John D. Hopkins (M).

Canadian Section

Douglas Andrew (A), J. L. Gardner (M), L. Hunter (M), Clarence D. Jacobs (A), Paul E. Lavery (M), Frederick R. B. Matthews (J), Melvin G. Sandell (A), Russell C. Workman (A).

Central Illinois Section

Norman R. Abernathy (A), James G. Jennrich (J), Joe Rush Jones (M), Richard Duane Kieser (J), William H. Springer (A).

Chicago Section

Robert G. Bielenberg (M), Roger S. Conrad (M), J. Arthur Gross (M), James G. Hanna (M), Homi Kapadia (J), John R. LeVally, Jr. (A), Roger R. Luther (J), James M. McAvoy (J), Walter T. Miiller (J), A. W. Risser (M), John E. Rosnell (M), Joseph J. Rossiter (M), Walter E. Schock (M), William J. Siekman (M).

Cincinnati Section

Leo Kaplan (M).

Cleveland Section

William J. Anderton (M), Ralph V. Denman (M), Robert B. Fell (J), George H. Hilderbrand, Jr. (J), Jack R. Kullman (M), Stephen P. Uhlik (A).

Dayton Section

J. Edward Ashworth (A), Paul R. Hughes (M).

Detroit Section

Robert J. Bailey (J), Kenneth J. Belmont (J), Raymond M. Bosworth, Jr. (M), James O. Brafford (J), Harry M. Buckingham (A), Howard C. Burns

New Members Qualified

continued

(M), Wu-Wai Chao (M), Curtis W. Copeland (A), Robert M. Cromwell (J), Edward T. Cruty (J), Edwin F. Dyer (M), Lloyd R. Enix (M), Eugene V. Fesler (M), Robert H. Fredericks (M), Carl E. Fredrickson (J), Raymond C. Haefner (M), Ronald E. Herman (J), Ernest A. Jackson (M), Albert A. Jadach (J), John J. Jakupco, Jr. (J), 2nd Lt. William R. James (J), Maurice D. Karlstad, Jr. (M), John S. Kerr (A), Ronald S. Knowles (J), William A. Kohn (J), Ernest C. Kron (M), Harold A. Kuypers (J), Casimir J. Lignowski (J), Harold E. Marcum (J), J. Horton Matthews (J), John A. McCabe (M), Anthony J. Muller (A), Charles Nielsen, Jr. (M), Albin J. Niemiec (M), Howard W. Noble (A), H. P. Oldham (M), Allan F. Omerza (J), George Harold Pickering (J), John M. Robertson (M), J. B. Rohrer (A), Erwin R. Schirs (M), Harold R. Seymour (M), Frank R. Spiaser (J), John G. Spruhan (M), Lawrence W. Steiner (A), Arthur F. Sullivan (J), Sydney W. Taylor (M), Paul T. Vickers (M), F. Roderick West (A), E. Joseph Whitcomb, Jr. (A), Arthur E. Woizeschke (M), Kenneth O. Young (J), John R. Zimmerman (J).

Hawaii Section

Clifford Geis (A).

Indiana Section

John W. Lubbers, Jr. (J), Jack Ryan, Jr. (A), David C. Shropshire, Jr. (J).

Kansas City Section

Harold L. Hildestad (M), Jack P. Woods (J).

Metropolitan Section

George B. Achtmeyer (M), Arthur V. Agresta (A), William F. Bland (A), Carl A. Carlsen (M), Joseph G. Costigan (A), John F. Creamer, Jr. (J), Edward J. Epp (A), Richard F. Finn (J), John P. Frain (M), Edmund D. Holland (M), Clarence E. Irion, Jr. (M), Lauren L. McMaster (A), Robert K. McQuiston (A), Hector Munro (M), William Nittel (M), Thomas L. O'Brien (A), Harry L. Richardson (M), Murray Rothberg (A), Caswell Speare (A), John L. Sullivan, Jr. (A), Donald W. Weed (M).

Mid-Continent Section

Donald G. Perkins (M).

Mid-Michigan Section

James F. Bourquin (M), Donald E. Dickson (M), Hugh H. Dorman (M), Jacob N. Groeneveld (M), Arthur L. Ott, Jr. (J).

Milwaukee Section

Percy Clemans (A), Carl A. Handtke (M), Lawrence P. Ludwig (M), Louis F. C. Pike (A), Leo Schwass (M), Alpheus Stevenson (M), Thomas L. Tannert (A).

Montreal Section

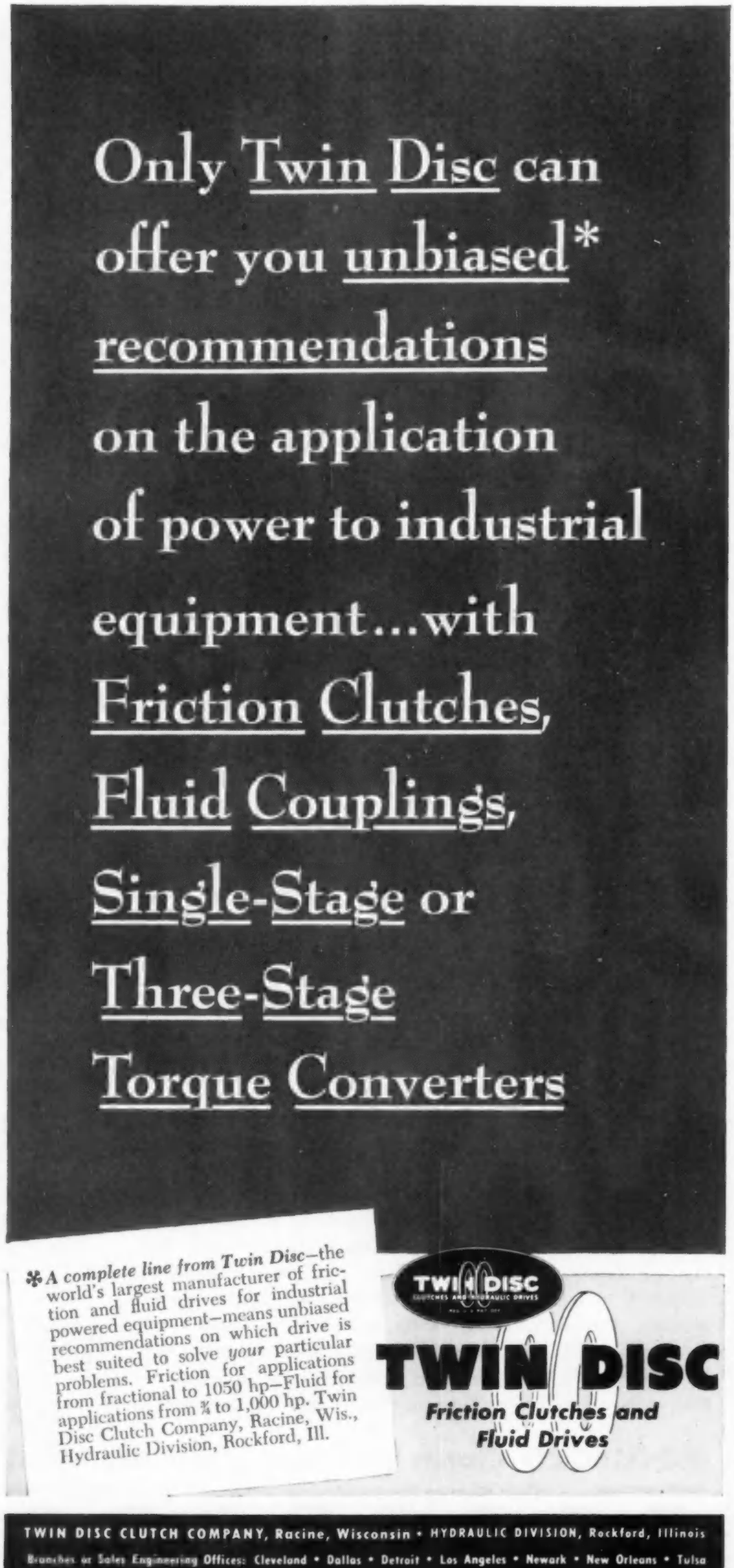
Richard F. Critchley (J), Rene Lavoie (A), Albert H. Palmer (A), George A. Pethick (A).

New England Section

Richard Leo McManus (M), Richard F. Shannon (A), Maurice Zabarsky (A).

Northern California Section

Ralph H. K. Cramer (J), Benjamin W. Dixon (M), Claude L. Fennema (M), Edward J. Putryae (M), Fred Stevens (M), Jack M. Vickland (M).



New Members Qualified

continued

Northwest Section

Bennie F. Dotson (J), E. J. Wood (A).

Oregon Section

Frederick J. Dryer (J), William H. Ferguson (A), Charles C. Hamilton (A).

Philadelphia Section

Herbert L. Forman (M), John Gattuso (M), John J. Greytak (J), David R. Kimber (J), Hans G. Krauss (M), Gerald D. Nepon (J), Franz J. Serdahely (A), Clifford A. Smith (A).

Pittsburgh Section

Donald R. O'Malley (M), William J. Weber (M).

Salt Lake Group

C. Allan Fechser (J), Robert W. Olin (M).

San Diego Section

Rocco V. Bucciarelli (M), Paul H. Whitmoyer (M).

Southern California Section

Herbert Caldwell (M), Robert L. Downie (M), Delton M. Lundberg (M), Peter Valenti (M), Timothy C. Walston (M).

Southern New England Section

William F. Brown (J), William R. Hamilton, Jr. (J), Le Roy C. Zastovnik (J).

Syracuse Section

Christian D. Gibson (M).

Texas Section

Robert H. Jay (A).

Texas Gulf Coast Section

Edgar Irvin Ballard (A), Roy H. Finefrock (M), James R. Miller (M), Frank J. Wehking (M).

Twin City Section

Robert W. Carlson (A), William J. Robertson (M).

Virginia Section

L. Dykes Meredith (A).

Washington Section

Walter K. Allen (J), Frank C. Schwager (M).

Western Michigan Section

Hubert Lee Childers (M), Raymond W. Lambrix (A), Frank L. Pecott (M), Harley R. Smith (M), Louis J. Van Slooten (M).

New Members Qualified

continued

Wichita Section

Donald L. Fowler (A).

Outside Section Territory

Harold K. Kienzle (M), Brigham A. Morgan (M), Charles M. Perkins (M), Hubert D. Songer (M).

Foreign

Joachim Arendt (M), Germany; George Alexander Brander (A), S. Rhodesia; Leon R. de Rosen (A), France; Peter N. Gates (M), England; John Derick Hopkins (M), England; Luigi F. Rapi (M), France; Roger V. Senez (A), France; Marcel G. Wachtel (A), Netherlands; Adolf Josef Wuensche (M), Germany.

Applications Received

The applications for membership received between May 10, 1956 and June 10, 1956 are listed below.

Atlanta Section

James W. Lucas, John L. Stoddard.

Baltimore Section

Robert G. Minty.

Buffalo Section

Francis J. Curran, Raymond Deibel, William J. Fritton, II, Robert W. Lally.

Canadian Section

William J. Budd, R. Bradley Hall, Andrew M. Johnston, Peter H. Lyon, Peter B. Mason, Gordon E. McMullen, Noel J. Meadows, Mervyn E. Nicholls, Alfred W. Pelletier, Melville A. Phipps, John H. Tanzer.

Central Illinois Section

Sami Akman, Pearl L. Breon, Jr., Stephen R. Davis, Edwin J. Eckert, Donald A. Hickman, Ray L. Schrader, Everett E. Sims, Clifford H. Springer.

Chicago Section

Oscar E. Anderson, R. G. Baumhofer, Ray P. Dunn, Frank G. Elmlinger, Avrum Gray, Paul C. Jones, Millard A. McCorkel, Leonard E. Olson, William W. Squier, Heinz Von Kroog.

Cincinnati Section

William J. Candler.

Cleveland Section

Roy V. Norrlander, James F. Ray, Frank W. Sharman, Theron J. Thaden, George W. Vollmer.

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Fuller ROADRANGERS provide extra *ability* with:

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- **One shift lever that controls all 10 forward speeds**
- **No gear splitting — 10 selective gear ratios evenly and progressively spaced**
- **Higher average road speeds — engines operate in peak hp range with greater fuel economy**
- **Less driver fatigue—1/3 less shifting**
- **Range shifts pre-selected — automatic and synchronized**
- **Space-and-weight-saving economies — the most compact 10-speed transmission available**
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To shorten trip time—to cut maintenance costs—to give *your* drivers complete control of every driving condition, specify Fuller semi-automatic ROADRANGER Transmissions.

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Unit Drop Forge Div., Milwaukee 1, Wis. • Shuler Axle Co., Louisville, Ky. (Subsidiary) • Sales & Service, All Products, West. Dist. Branch, Oakland 6, Cal. and Southwest Dist. Office, Tulsa 3, Okla.

Applications Received

continued

Colorado Group

Hubert N. Allen, Arthur L. Haubert.

Dayton Section

Charley R. Aycock, John W. Carlisle, Hobart A. Cress, Frederic B. Doege, John J. Warga.

Detroit Section

Charles H. Becker, Thomas G. Berry, Kurt C. Binder, Kenneth E. Brooker, Robert W. Brown, Roy A. Brown, Jr., Clare L. Caswell, Theodore Cicero, Norman B. Cox, Noel N. Cumming, Stephen M. Daniska, Joseph L. Dodd, Robert A. Doerr, Harold R. Droste, Henry N. Fedorchuk, Michael Ference, Jr., Leonard E. Froslie, Nilo Fuciarelli, Raymond L. Gee, Peter W. Gerstmann, Harvey L. Gilchrist, Oliver D. Hanna, Jr., Walter K. Heintz, Theodore C. Hobbs, Carl P. Kalocsay, Donald J. Kiesgen, John Kloian, Jr., John J. Krauss, Gordon G. Krey, John J. Lenosky, Bernard Lis, Alexander L. Madyda, Louis Mallouf, Salvatore A. Manera, William Margolin, Richard W. Mattson, Gerald L. McArthur, Samuel J. McCracken, Jr., Peter A. McKinney, William J. Molnar, James Nagy, David J. O'Leary, Albert P. Oot, Jr., John Pelzak, Robert M. Phillips, William E. Pinkerton, Vincent Rotole, Corado R. Salet, Franklin C. Schoonover, George B. Seifried, Theodore J. Sheehy, Edward Shell, Arthur M. Smith, Joseph V. Svatora, Chi-pieng C. Tan, J. Wilbur Tatter, Edward Warzybok, Lyle R. Weiss, James R. Wickham, Stanley W. Wolfe, Bruno Zava, Richard M. Zeek.

Hawaii Section

Claude F. Bartlett.

Indiana Section

John I. Firth, Jr., Frederick W. Kerby, Herman J. Maurer.

Metropolitan Section

Charles A. Benson, William A. Burnett, Richard E. Call, Jules Gilbert, Benjamin T. Hill, Jr., Norman B. Hirsh, Ray Matlock, Emil J. Novak, Marshall W. Novick, Joseph C. Scopinich, Hugh A. Souman, Stanley L. Ulc.

Mid-Continent Section

Joseph E. Morrow.

Mid-Michigan Section

Gerald Case, Albert Macciomei.

Milwaukee Section

Loren G. Pless, Wesley D. Tomlinson, Jr.

Mohawk-Hudson Section

Libbus Lewis, Joseph J. Waldron.

Applications Received

continued

Montreal Section

A. S. Lowe.

New England Section

Donald S. Lee.

Northern California Section

Neo Corsini.

Oregon Section

Rollin W. Fishwood, Edward J. Salata.

Philadelphia Section

Alfred M. Di Bartolo, Marshall C. Pritzbur, Harold J. Schell, Charles N. Smith, Eugene D. Tarris, Kenneth E. Wright.

Pittsburgh Section

Kenneth H. Carlson, Alan A. Glaser, William P. Rowles.

St. Louis Section

Ellis A. Schmidt.

Southern California Section

Richard B. Ault, James P. Brown, Charles C. Busenkell, Leo A. Carter, Wesley P. Harris, Collis H. Holladay, Jr., John F. McCloskey, Rolland Moody, Charles S. Ross, Edward B. Thompson, Richard C. Turner, Robert S. Welther, Keith A. Wilhelm.

Southern New England Section

Walter E. Froehlich, Wayne R. Lundberg, Wayne MacKown.

Texas Section

Donald E. Herbert.

Twin City Section

Kenneth F. Burke.

Washington Section

Mario Matacotta.

Wichita Section

Archie E. Campbell.

Williamsport Group

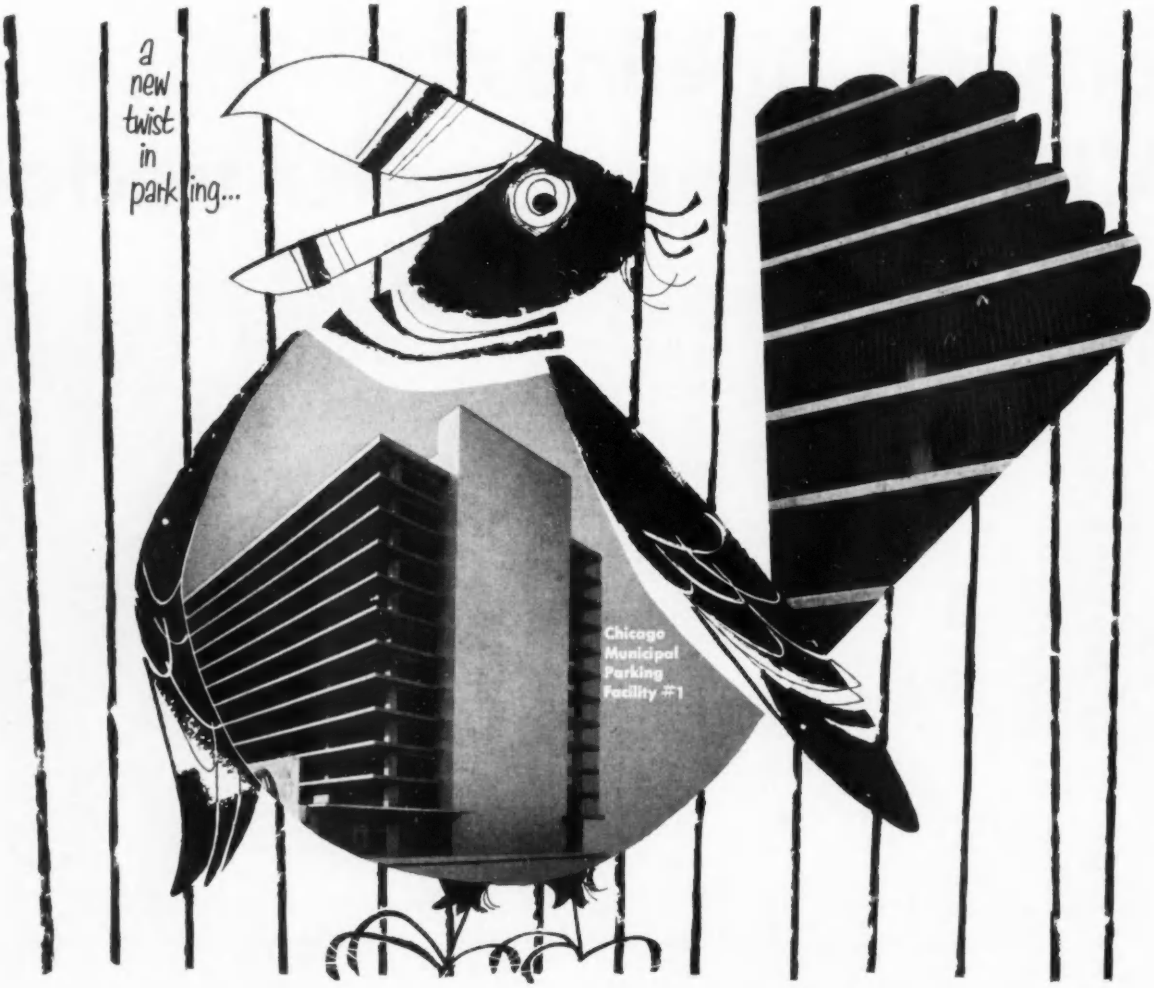
Frederick D. Burnham, Jr., Robert L. McCumber.

Outside of Section Territory

Kelly F. Harrouff, Wildrick Hart, Ronald P. Holmes, Albert W. Melvin, George P. Nelson, Charles A. Ropes, Jr., Oliver I. Snapp, Jr., Richard H. Swartz.

Foreign

Juan J. A. Ayala, Spain; Richard Hoon, Holland; Toufic Rached Houry, Lebanon.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As-rolled, without heat-treatment, steels of this type show a 50,000 psi minimum yield point, or about 1½ times that of plain carbon structural steel. Sheet gauges may be cold formed into structural panels that cut weight substantially, without sacrifice of strength or safety.

In addition, high strength low alloy nickel-copper steels offer 4 to 6 times greater resistance to atmospheric corrosion than do carbon steels. Thus, they retain a high degree of original strength. They also offer superior resistance to shock, battering and abrasion. As a result, use of these nickel steels extends the life of fabricated structures.

Moreover, high strength low alloy nickel-copper steels readily respond to fabrication processes, including welding. These steels, containing nickel along with other alloying elements, are marketed under a variety of trade-names by leading steel companies.

Get full details in "Nickel-Copper High Strength Low Alloy Steels" . . . *your manual* for the asking. It discusses design factors that cut weight safely, explains why these alloy steels resist atmospheric and other types of corrosion, describes behavior in fabrication, and illustrates scores of applications. Write for this manual now.

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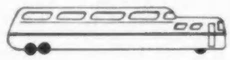

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Roaring away at 58,000 rpm, a diesel turbocharger impeller blasts a miniature tornado into the engine cylinders.

In effect the impeller blades are *airfoils*, operating in the supersonic vicinity of Mach One. To prevent turbulence and cavitation, the impeller blades must be very thin, very smooth and very delicately shaped. Needless to say, the impeller must also be very well balanced, very strong and not too expensive.

That's the problem a turbocharger manufacturer gave our Development Division. He was thinking in terms of permanent-mold castings. But we decided that our revolutionary *plaster casting* process offered the best possibilities and we set out to lick the complex technical problems.

Result: The plaster castings perfectly reproduced the delicate curved blades, with leading edges tapering to an air cleaving 0.020″. (Much thinner than is possible with other casting methods.) The surface finish, at 125 microinches, keeps surface friction to a low level.

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The customer was delighted with the impeller, especially after it withstood operating tests of 70,000 rpm with no hint of failure. Nor did the cost make him unhappy.

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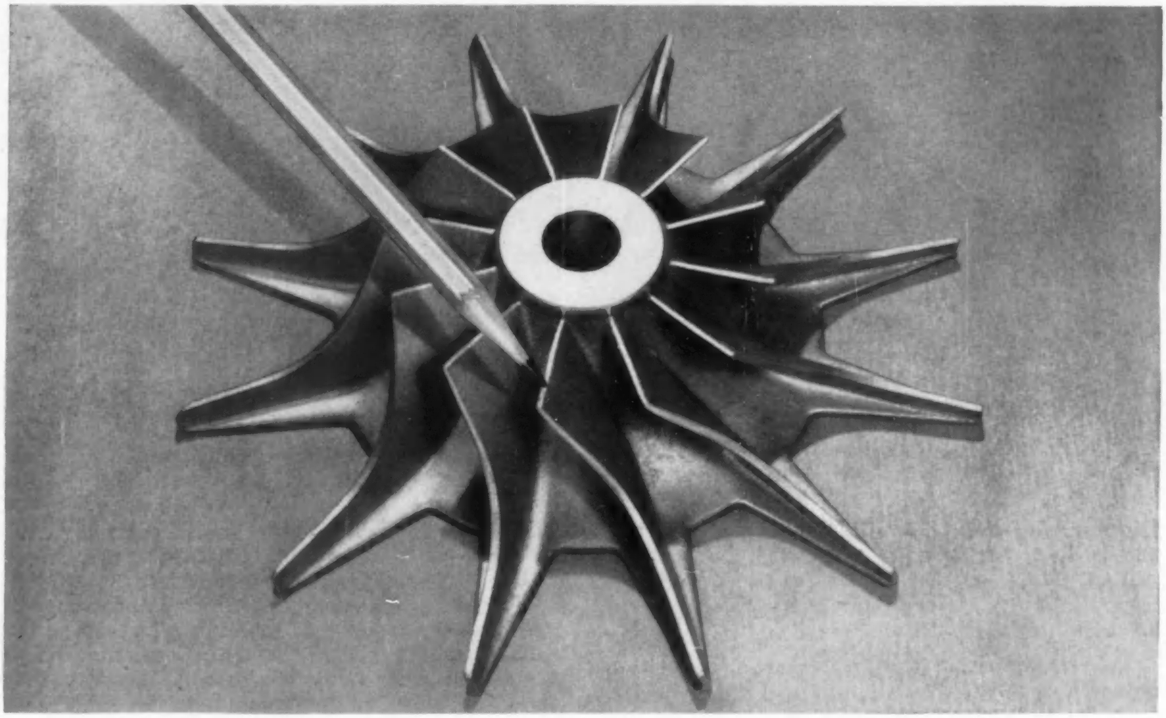

For this 58,000 rpm impeller, used in the diesel turbocharger made by Schwitzer Corporation, of Indianapolis, Alcoa Development Division engineers recommended our revolutionary plaster casting process. Result: Great accuracy, fine surface finish. Let our superbly equipped Development Division help you imagineer in Alcoa Aluminum. Aluminum Company of America, 1844-G Alcoa Building, Pittsburgh 19, Pennsylvania.

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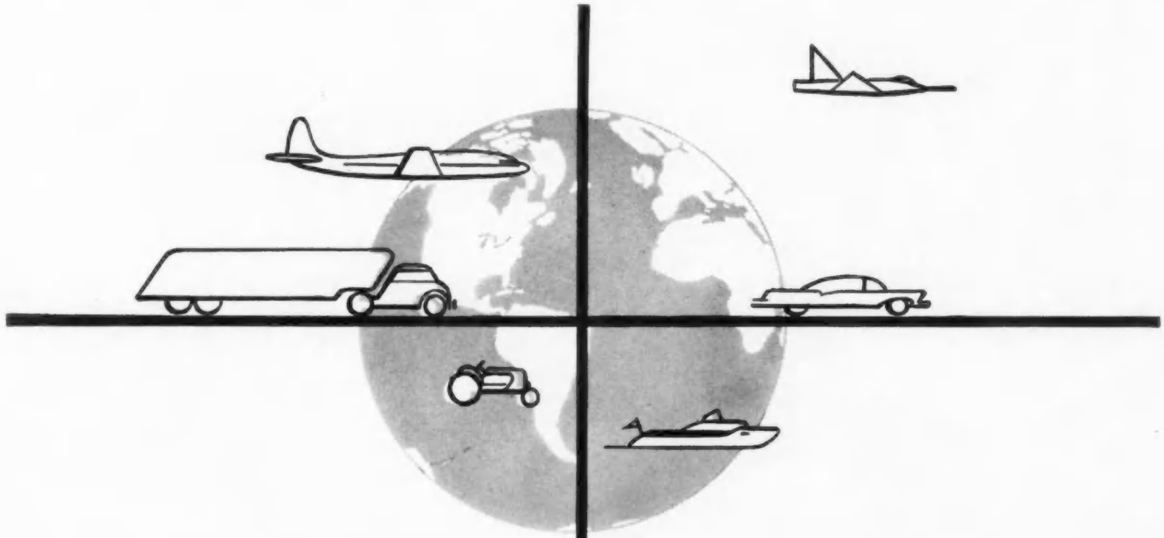

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R/M alone manufactures all types of friction materials

Particularly with today's more complex requirements, no single type of friction material can be best for all friction applications. That's why R/M (and only R/M) manufactures *all* types of friction material. And that's why you can be sure of getting the material or combination of materials best for you when you consult R/M.

Where asbestos is most practical for your purpose, R/M experience can determine precisely whether woven or molded asbestos parts—or both together—will give you better performance. R/M's experience with asbestos is second to none in the field.

Where kinetic energy absorption per square inch of friction material is very high, where engagements occur on a repetitive cycle with little time interval, or where friction components must be held to a minimum thickness, R/M sintered metal friction parts, for oil or dry operation, may best meet your requirements. Under such severe conditions, R/M sintered metals will perform without appreciable increase in wear rate because of their high thermal conductivity and the absence of a destructible bond.

If high temperatures are not a factor, R/M cork-cellulose materials may give top performance. The most popular type for operation in oil is a composite consisting of a dual-faced assembly with alternately opposed nesting rings of cork and cellulose. The friction properties are at the top of the range. The engagement characteristics are good. And the natural dampening characteristics tend to prevent chatter.

Cork and cellulose materials, however, char to destruction at temperatures close to 400°F. Where higher heat resistance is required, R/M semi-metallic friction materials are widely used. Their durability is much greater than that of resilient types, their engagement characteristics are comparable, but their friction range is lower.

There is some drop-off in friction during the life of semi-metallic materials, but stability of friction under relatively severe operating conditions is one of their recognized advantages. Their versatility is important, too, for they can be made in thin, conformable sections readily adaptable to such uses as bands, plates, cones and intricate shapes.

Woven and molded asbestos, sintered metal, cork-cellulose, and semi-metallic are but five types in the complete R/M line covering all kinds of friction material. Thus, whatever your friction requirements may be—whatever the application—Raybestos-Manhattan is in a unique position to supply the exact friction parts for your purpose.

Remember—next time you have a friction problem—that R/M alone works with *all* friction materials. And remember that all the depth and breadth of R/M experience—the complete facilities of R/M's seven great plants with their research and testing laboratories—are as near as your telephone to help you solve it.

Write for your free copy of R/M Bulletin No. 500. Its 44 pages are loaded with practical design and engineering data on all R/M friction materials.

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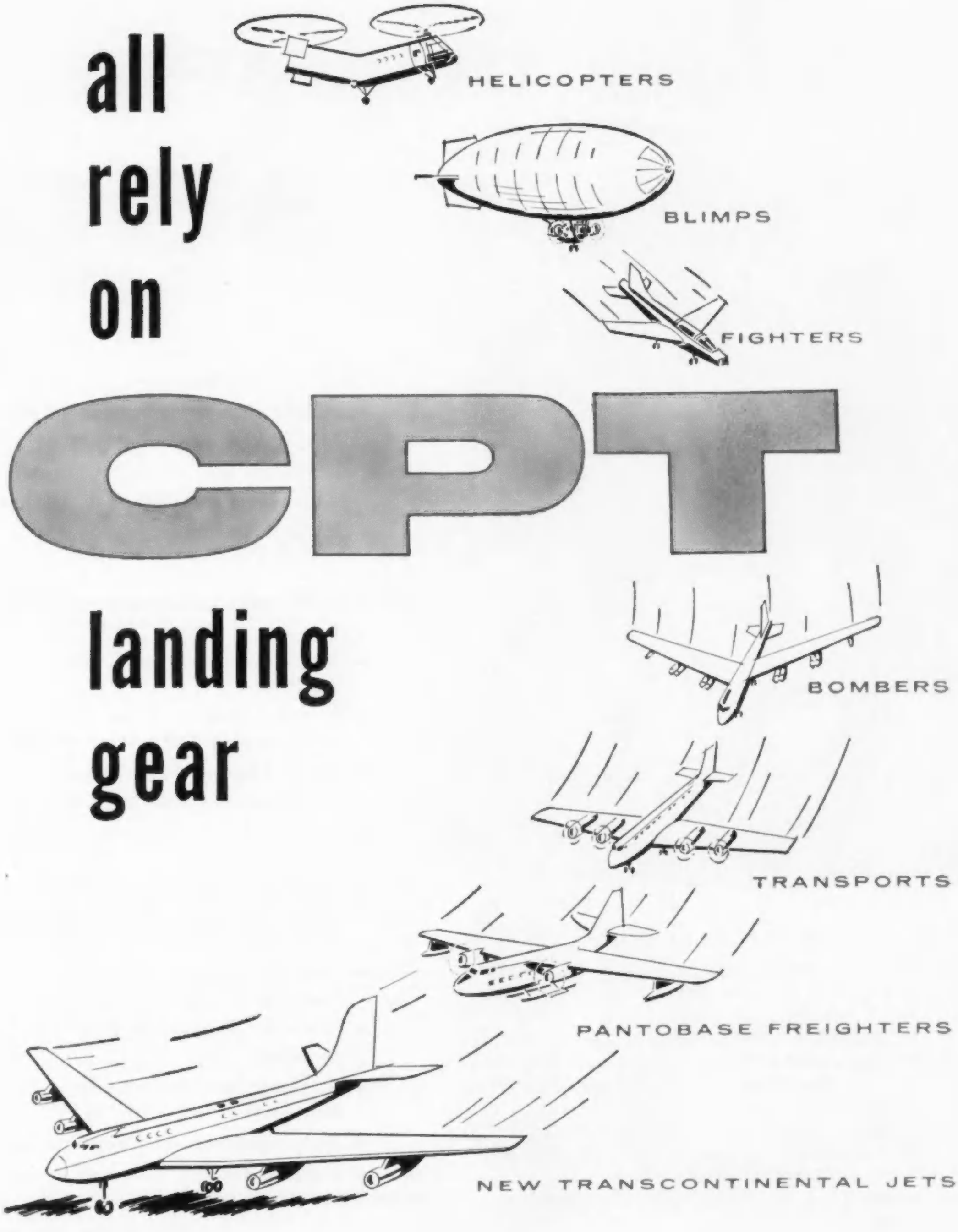

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Tool Company CLEVELAND 5, OHIO

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ROLL-FORMED
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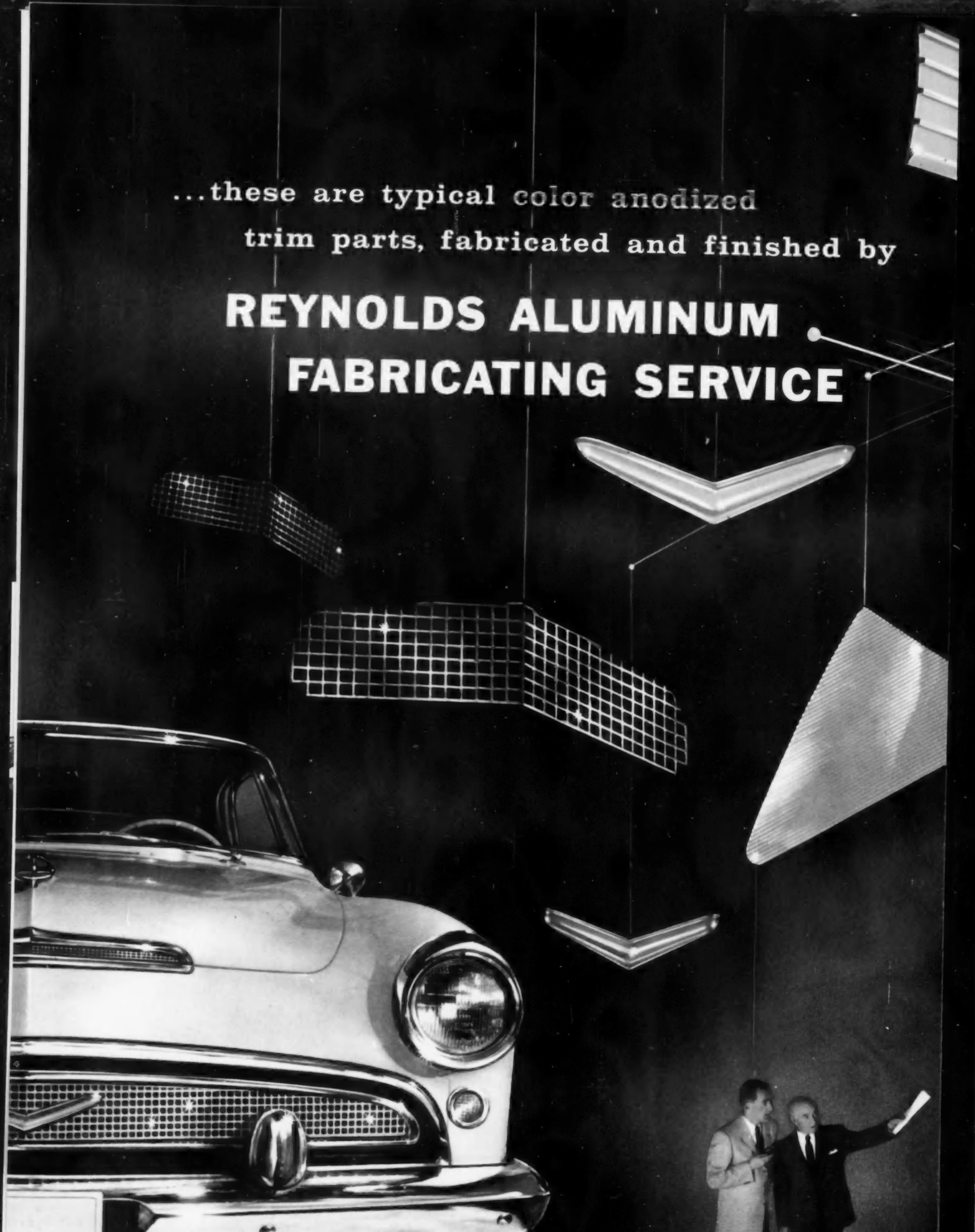
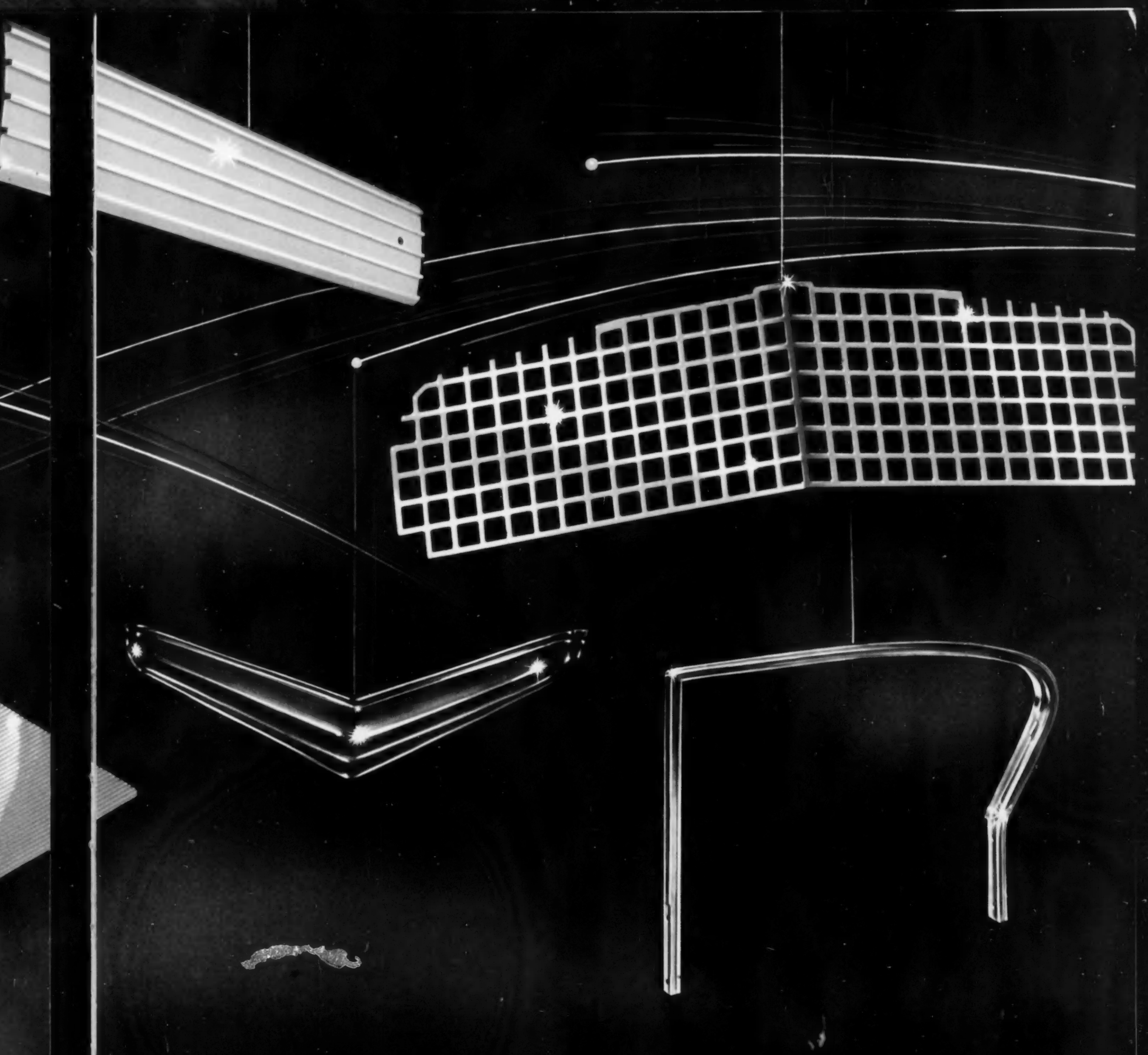
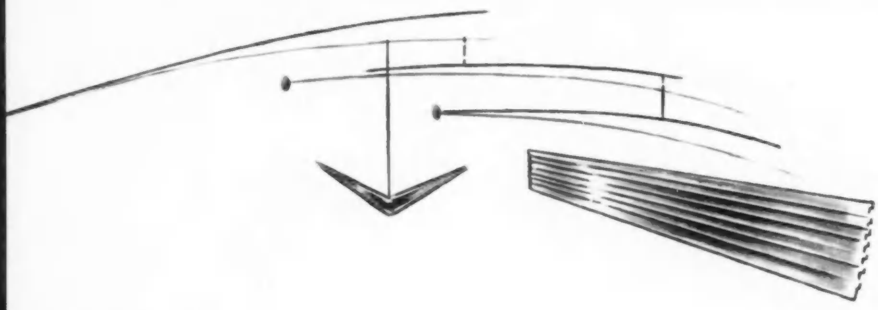


...these are typical color anodized
trim parts, fabricated and finished by
REYNOLDS ALUMINUM
FABRICATING SERVICE



Here's why it pays to consider
REYNOLDS ALUMINUM FABRICATING SERVICE
for production of quality automobile parts and trim



Vast fabricating facilities, experienced design and engineering assistance and quality control from mine to finished product are

3 GOOD REASONS WHY...

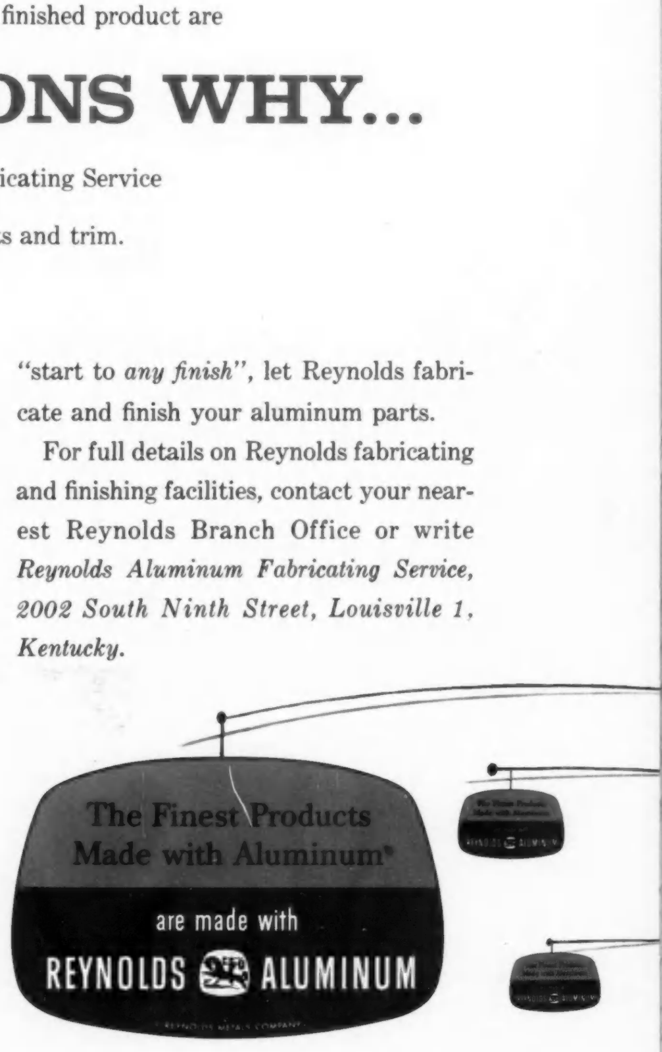
it pays to rely on Reynolds Aluminum Fabricating Service for production of aluminum automobile parts and trim.

AND–

Reynolds extensive finishing facilities have been expanded by the installation of today's latest automatic finishing equipment. This tremendous investment by Reynolds offers you finishing facilities unsurpassed anywhere. Assures you finer finishes on the aluminum parts you design. Gives you new flexibility in your design thinking. Reynolds years of technical experience with practically every finishing process and technique applicable to aluminum go hand in hand with these expanded facilities.

For *color anodized* finishes in new gold or blue or other gleaming colors—in-the-metal finishes that will never pit or chip or flake or tarnish . . . for *clear anodized* finishes with the mellow luster and the "look of sterling"...for all types of *electrolytic, chemical, mechanical* and *paint film* finishes . . . for the highest quality from "start to *any finish*", let Reynolds fabricate and finish your aluminum parts.

For full details on Reynolds fabricating and finishing facilities, contact your nearest Reynolds Branch Office or write *Reynolds Aluminum Fabricating Service, 2002 South Ninth Street, Louisville 1, Kentucky.*



REYNOLDS ALUMINUM FABRICATING SERVICE

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AUTOMOTIVE ENGINEERING NEWS

PROPERTY AND APPLICATION DATA
ON THESE VERSATILE ENGINEERING MATERIALS:
"ZYTEL," "ALATHON," "TEFLON," "LUCITE."

No. 3, 1956

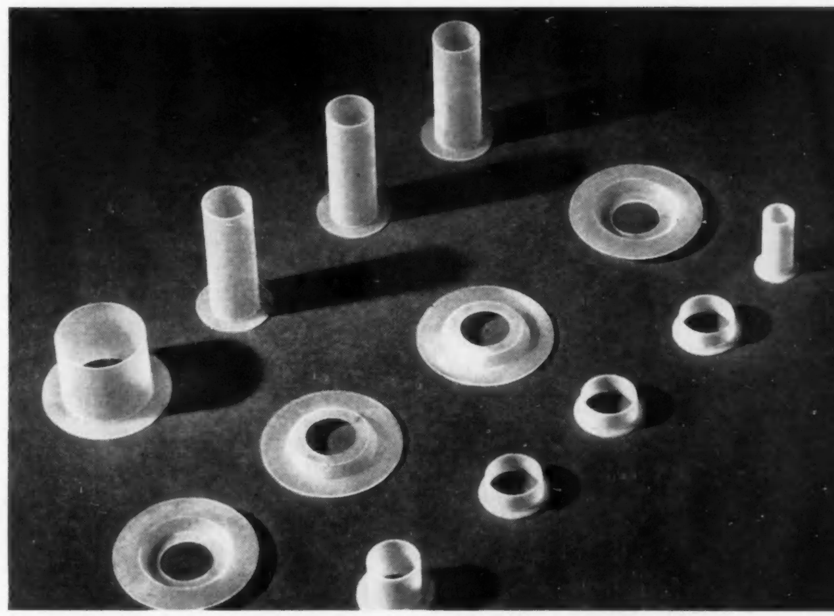
Bearings of ZYTEL® nylon resin resist wear ...can operate with or without lubrication

Simple sleeve bearings of "Zytel", with lubrication, can support loads up to 1,000 lbs. psi at rubbing velocities up to 500 feet/min.

The physical properties of Du Pont "Zytel" nylon resin are particularly applicable to the field of automotive engineering. The strength, heat resistance, resilience and lightness in weight of "Zytel", coupled with its moldability, have already been put to use in many specific jobs.

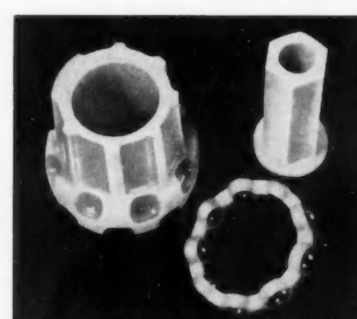
"Zytel" as a bearing material is unique in that it can perform satisfactorily over a useful range of loads and operating conditions, with little or no lubrication. This characteristic is extremely valuable for bearings which must operate in hard-to-reach spots where lubrication is a problem. The resistance of "Zytel" to oils, gasoline and grease further expands its range of usefulness.

Of equal interest are the design possibilities that exist with *lubricated* bearings of "Zytel". Recent Du Pont laboratory tests revealed that simple sleeve bearings of "Zytel", under conditions of hydrodynamic lubrication, can support loads up to 1,000 psi at rubbing velocities up to 500 fpm with negligible wear. These tests also revealed that with "Zytel", hydrodynamic lubrication can be maintained with a minimum amount of lubricant present. In one case, with only an initial lubrication of a bearing, the bearing operated continuously for 41 days without increase in temperature or torque.



These brake-pedal bushings and window crank-handle bearing plates are made of "Zytel". The parts give smooth, quiet operation and provide long-wearing bearing surfaces which, after assembly, do not have to be lubricated for the life of the vehicle.

It may pay you to examine your own automotive-design requirements with "Zytel" in mind. If you have a bearing-design problem, consider these many advantages of "Zytel". It may help you cut costs, simplify production and increase operating efficiency. For the most recent specific information and test data, fill out and mail the coupon below.



Representative bearings and bushings of lightweight "Zytel" nylon resin feature excellent abrasion resistance, toughness in thin sections, heat resistance and resiliency.

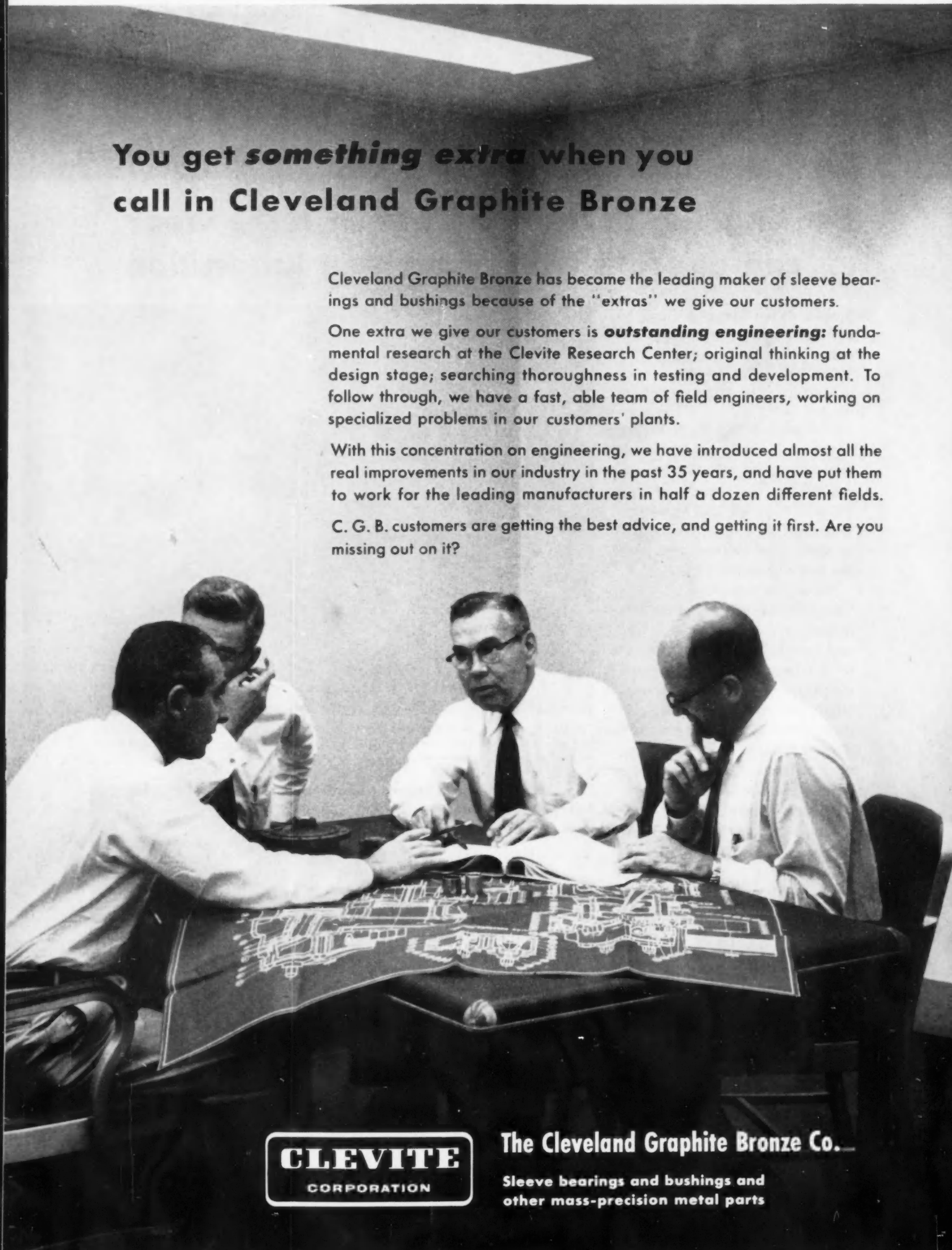
NEED MORE INFORMATION?

For complete details that will help you further evaluate Du Pont "Zytel" for use in your product development program, mail the coupon at the right.

E. I. du Pont de Nemours & Co. (Inc.)
Polychemicals Department, Room 467, Du Pont Building, Wilmington 98, Delaware

Please send me more information on Du Pont "Zytel" nylon resin. I am interested in evaluating this material for__________

NAME__________ TITLE__________
COMPANY__________
STREET ADDRESS__________
CITY__________ STATE__________
TYPE OF BUSINESS__________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Cleveland Graphite Bronze has become the leading maker of sleeve bearings and bushings because of the "extras" we give our customers.
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With this concentration on engineering, we have introduced almost all the real improvements in our industry in the past 35 years, and have put them to work for the leading manufacturers in half a dozen different fields.
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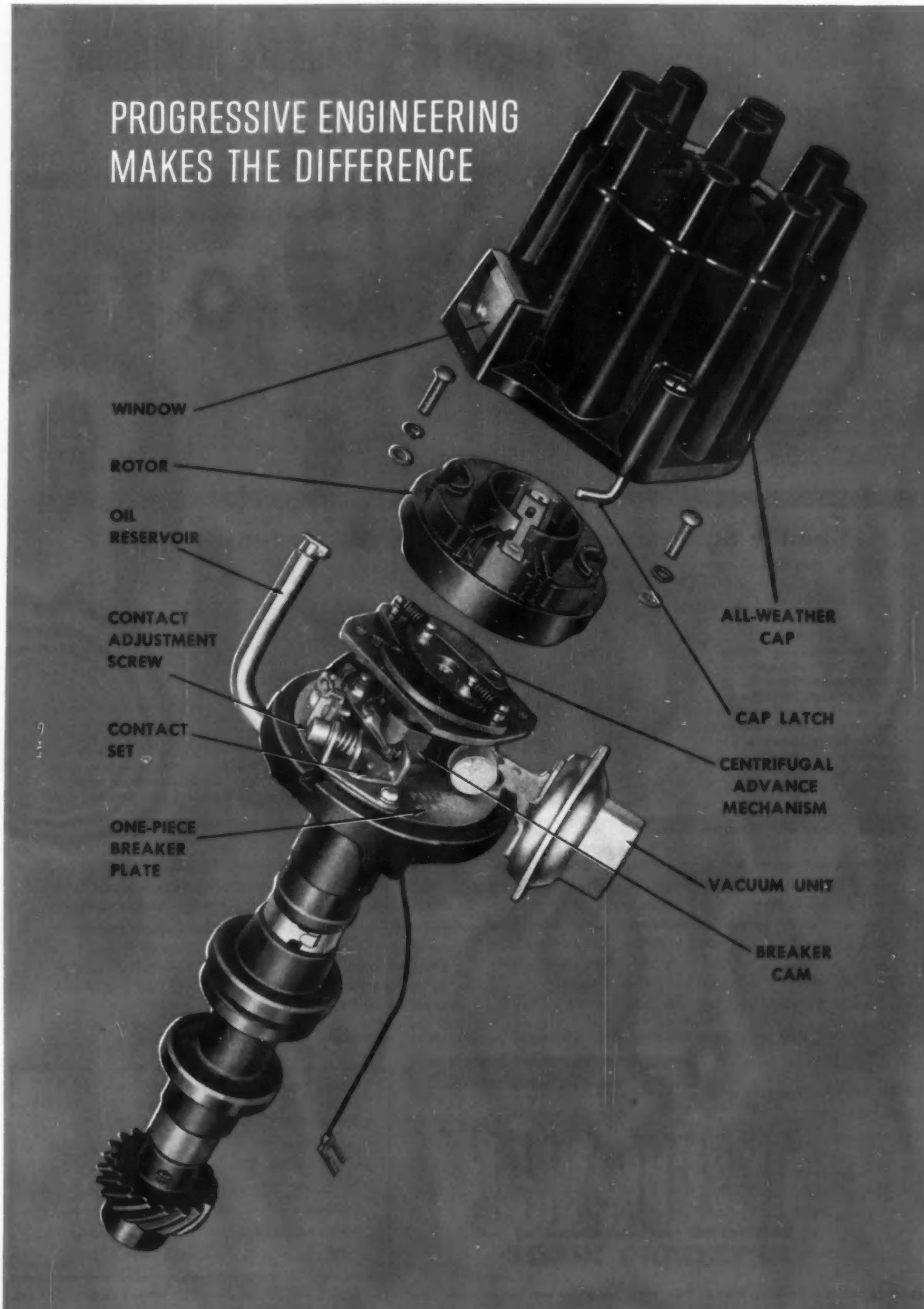
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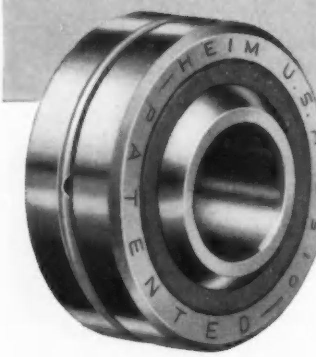
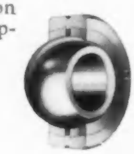
HEIM *has a bearing* FOR YOU

With a half century of experience in the anti-friction bearing industry, it was only natural to expect from The Heim Company origination of the modern methods in producing Unibal, the single ball spherical bearing.

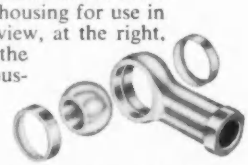
Heim pioneered not only in the perfecting and manufacture of the spherical bearing, but in its introduction to American, as well as foreign, manufacturers.



The single ball (Unibal) construction, because of its free action, compensates for shaft misalignment and deflections in all directions. There is ample provision for lubrication around the ball, and the greater supporting area carries heavier loads.



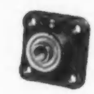
This is the Heim Unibal Rod End. It operates on the same principle, but is mounted in a suitable housing for use in push-pull applications. The exploded view, at the right, shows the two bronze bearing inserts (the race) ready to be expanded into the housing and around the ball.



Heim Unibal Spherical Bearings are available in a wide range of stock sizes, the Rod Ends are made in both male and female types, and complete stocks are carried by bearing distributors throughout the country.

It is not only the low price of the Unibal Rod End, but the simplicity of attaching it that bring the overall cost down. Many applications require only a drilled and tapped hole for the male rod end — or a drilled hole, with a bolt or screw for the female type.

Please write for complete catalog and name of nearest Direct Factory Representative or Distributor. Heim Unibal is also manufactured, under license, in England, Germany, Switzerland and other European countries.



SELF ALIGNING
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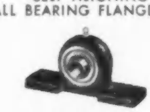

SELF ALIGNING
BALL BEARING PILLOW BLOCK

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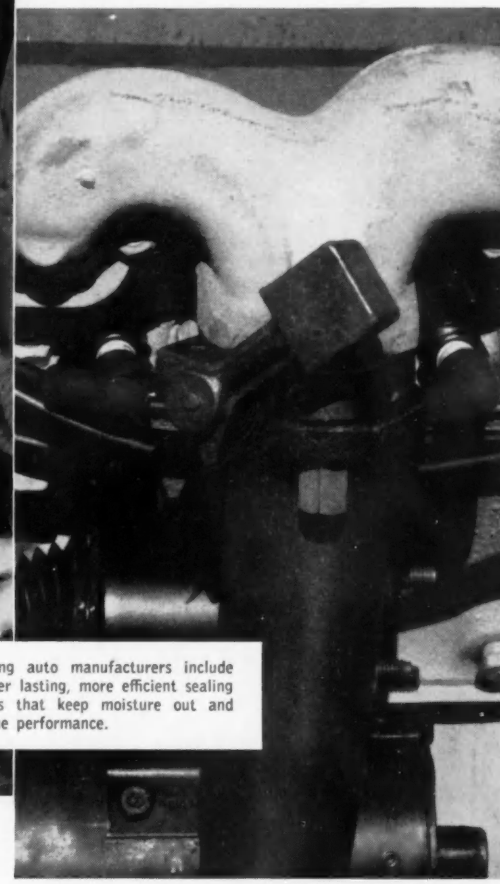

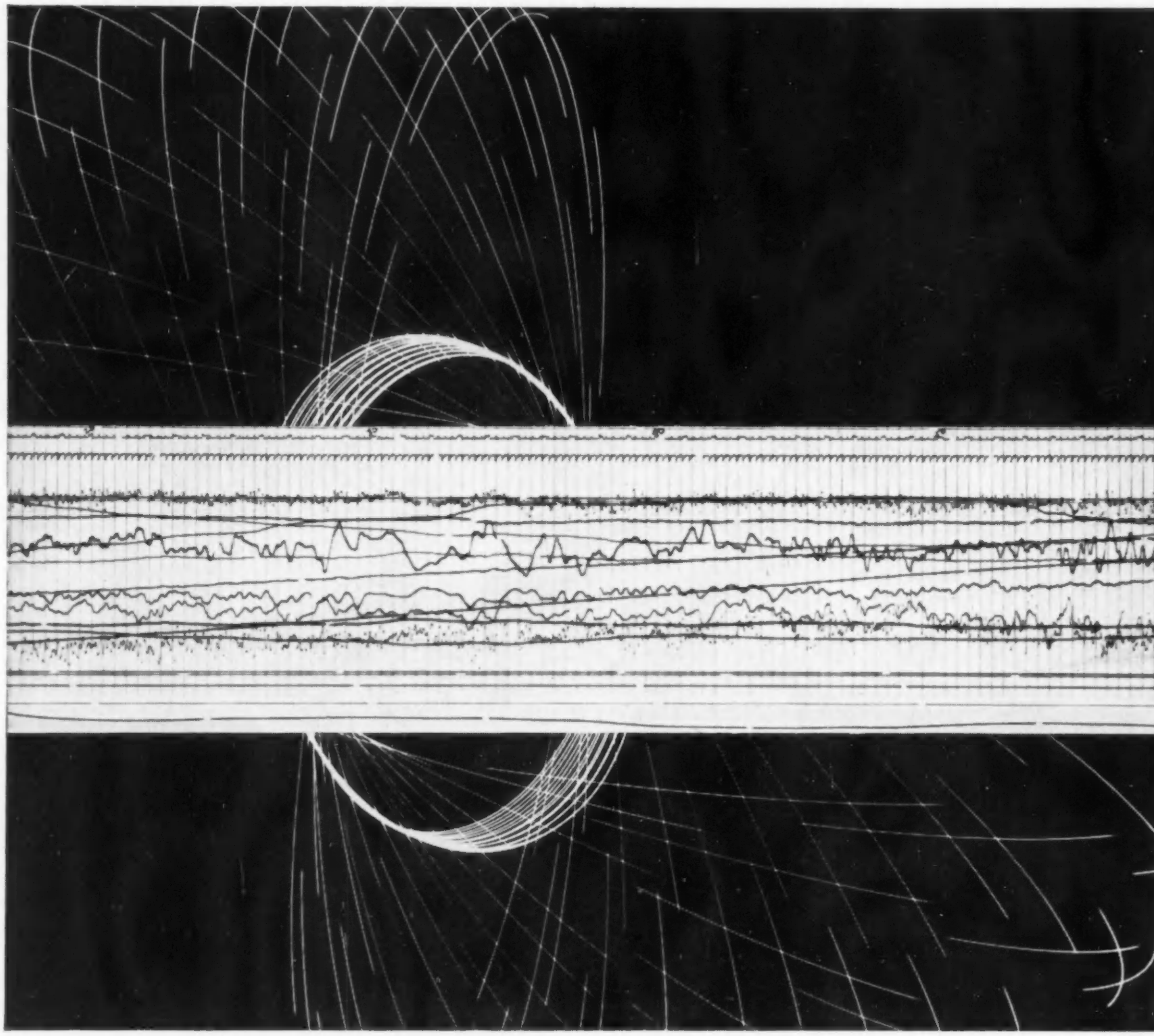

Getting information firsthand—a Du Pont automotive specialist accompanies representatives from the engine manufacturer and fuel supplier on a customer visit. Adding Du Pont FOA-2 and DMD to the fuel may help solve your problem.

How you can take advantage of Du Pont's new technical service on diesel problems

As you doubtless know, downtime of diesel engines is understandably serious to operators because it means loss of income. And performance complaints from big fleet customers can jeopardize a substantial amount of business.

Injector-sticking and filter-plugging are among the most annoying diesel engine operating problems. They involve the fuel composition as well as the engine design. In many cases, diesel fuel additives provide the easiest and most efficient solution. We at Du Pont are interested in cooperating with fuel suppliers on these problems.

To help you satisfactorily answer customer complaints, our Petroleum Chemicals Division automotive specialists will be glad to work with your own men. The practical experience which our men have had in working on this type of problem can be put to your use. And the facilities of our five conveniently located regional laboratories, as well as the Du Pont Petroleum Laboratory, can also aid you in this work.

In many cases of filter-plugging—in both truck and tractor fleets—our service representatives have found that Du Pont Fuel Oil Additive No. 2 (FOA-2), or a combination of FOA-2 and Du Pont Metal Deactivator (DMD) in the fuel will help prevent the trouble. FOA-2 has also solved injector-sticking problems in several types of diesel engines. However, since engine designs and diesel fuel stocks vary, each problem must be studied on an individual basis.

If your diesel engine customers are encountering fuel problems, we're sure it will pay you to talk them over with one of our automotive representatives. You can get in touch with one at any of our offices listed below.

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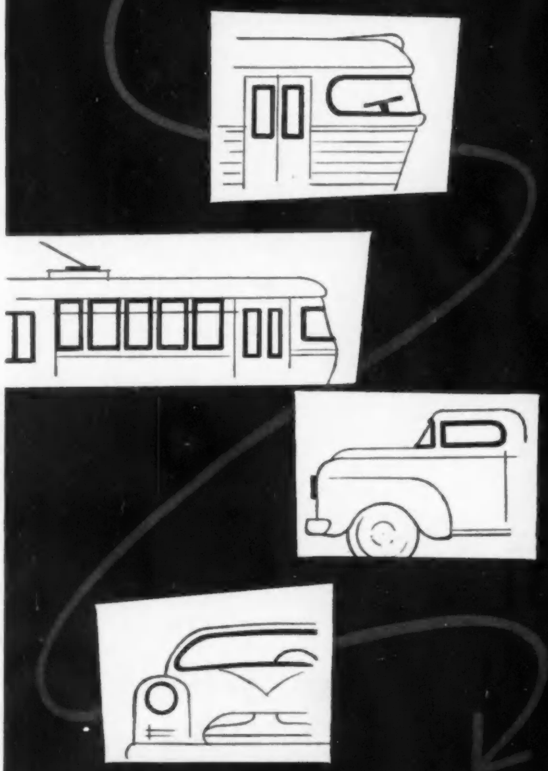
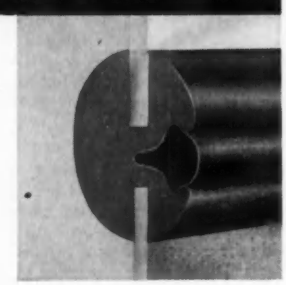
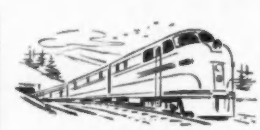




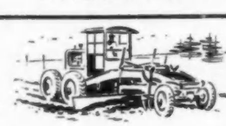
Transportation Industry

Automotive Installations



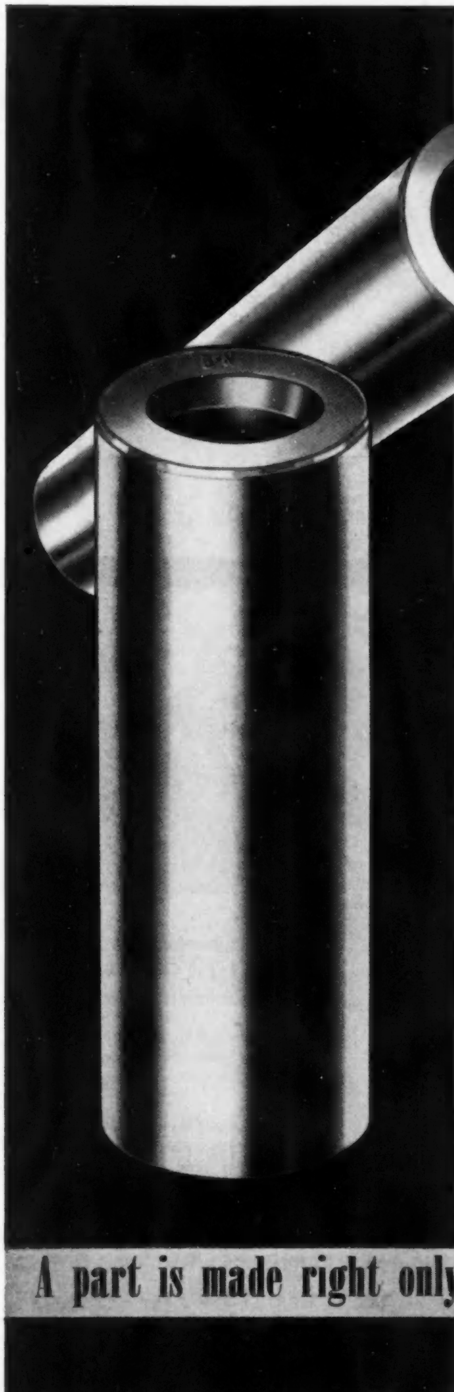
Railway Equipment

Marine Applications



Over-the-road Equipment

Commercial Structures



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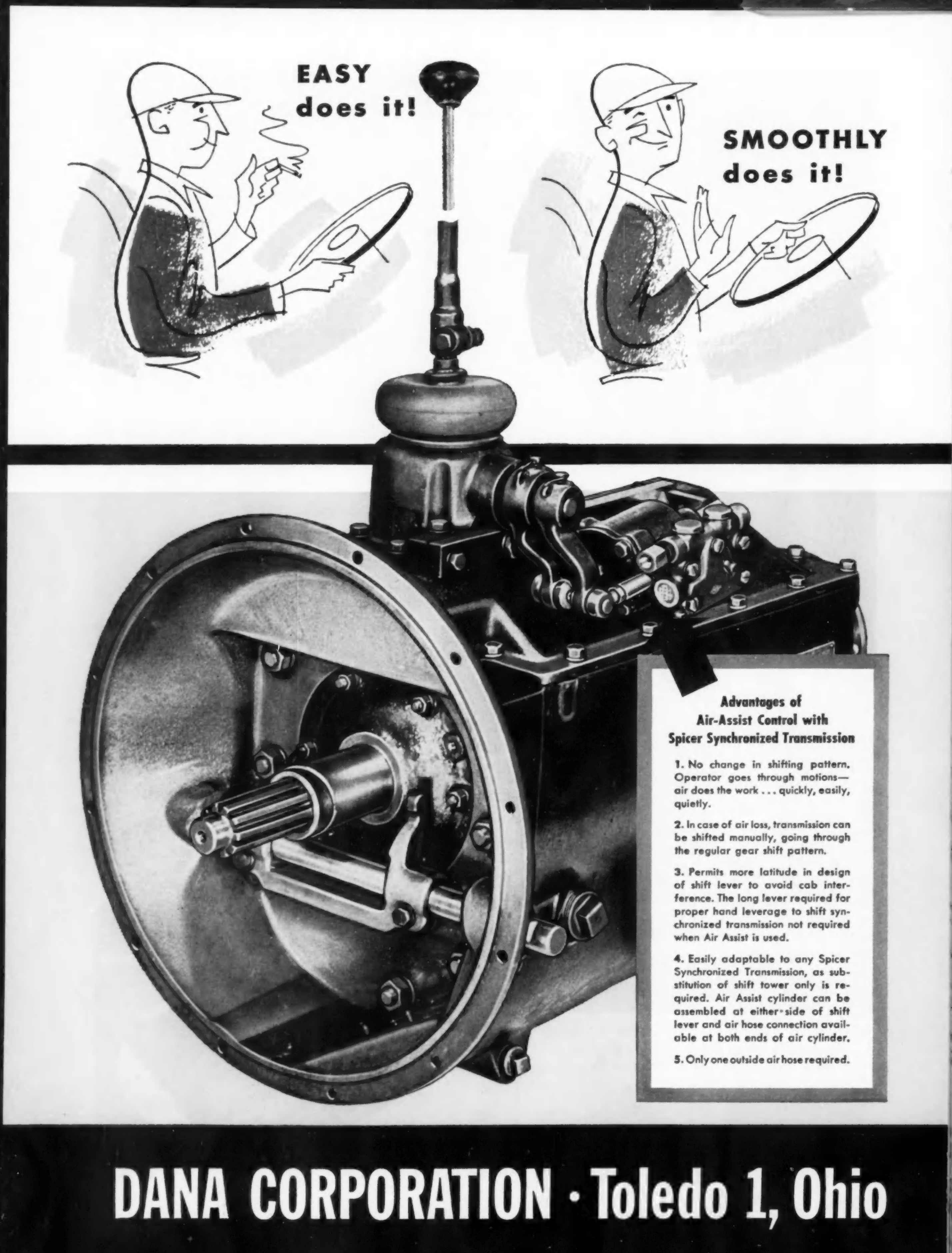
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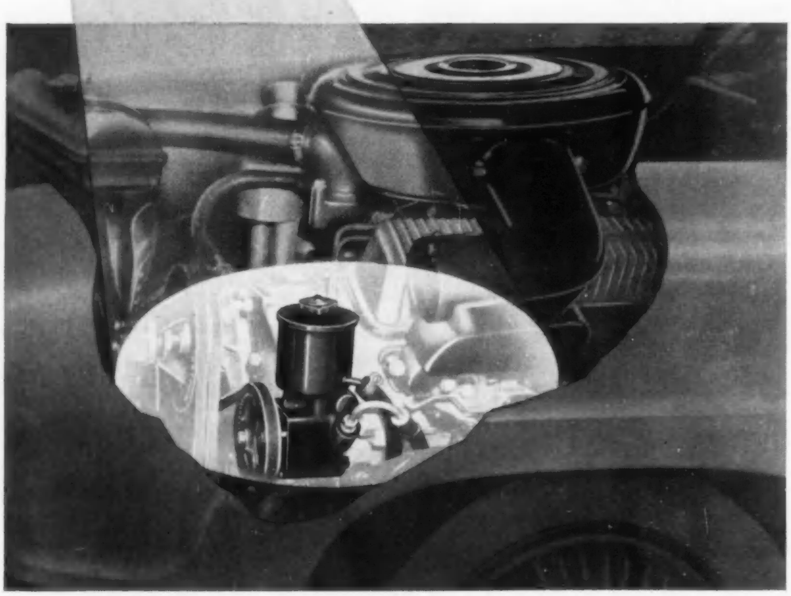
FOR POWER STEERING



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Vickers advance-minded engineering and production "know-how" score again. Pulley-driven from the engine crankshaft, a new Vickers Vane Type Pump provides hydraulic power for steering Ford Motor Company's luxurious Continental Mark II. The Series VT26 unit is a compact pump design . . . saves space, saves weight . . . has the time-proved Vickers Pump advantages of exceptional dependability, long life, high efficiency and quiet operation.

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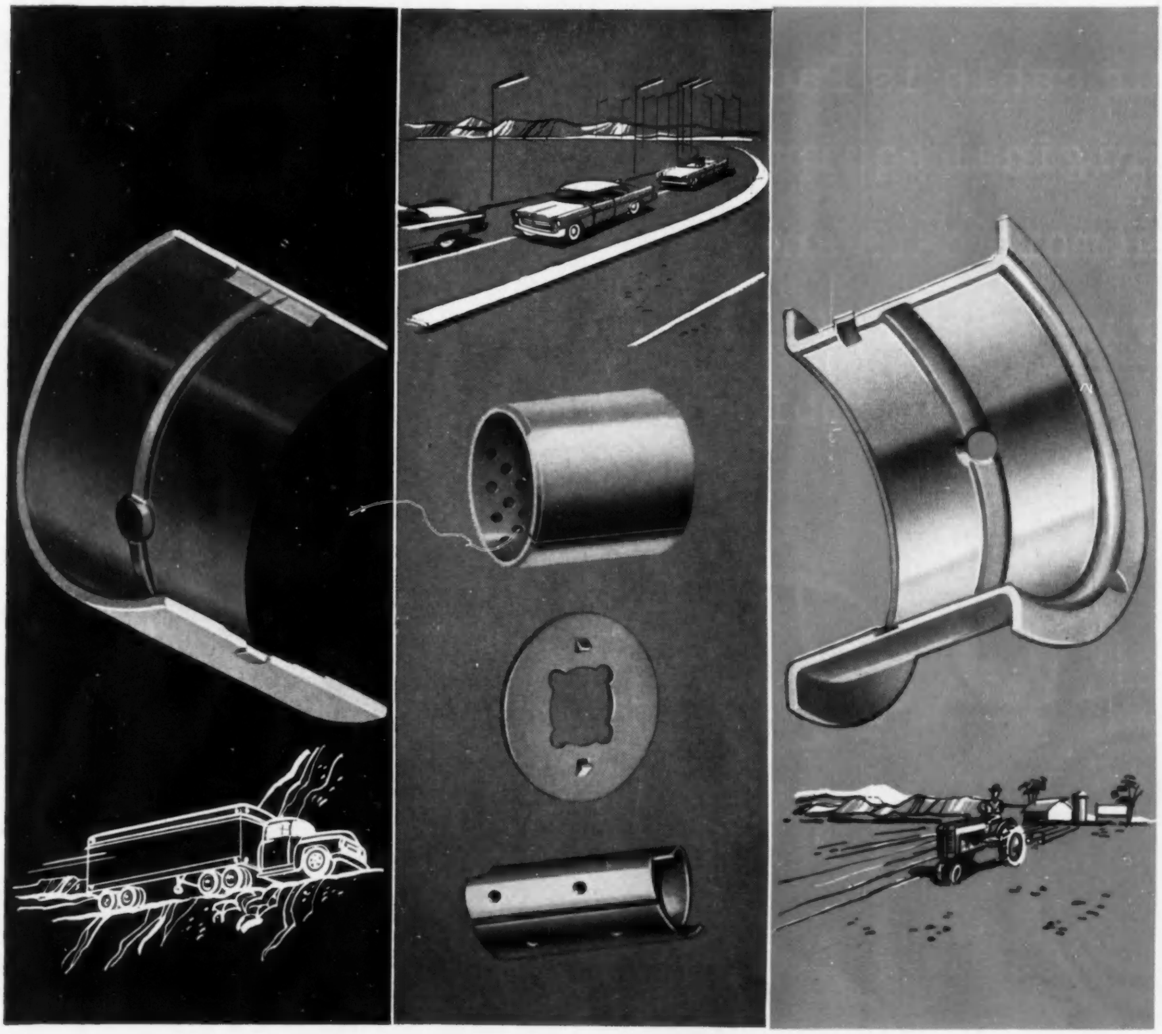

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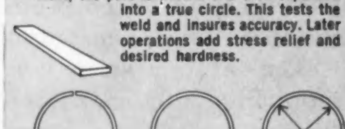

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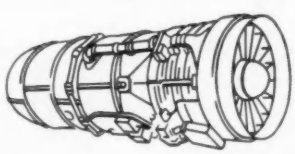

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Trade-Mark

Flame-Plating — a remarkable detonation process — is now being used to coat metal parts with a thin coating of tungsten carbide or aluminum oxide. Results from experience with parts in actual use show that Flame-Plating solves many problems of wear, abrasion, and fretting corrosion.

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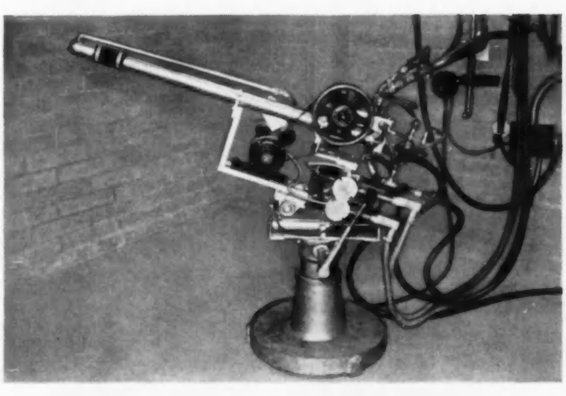
Flame-Plating applications have been proved in service. Parts for aircraft and rocket power plants, hydraulic systems, and heating units, as well as various types of plug and ring gages, bearings and seals, and dies have had their useful lives considerably extended—economically—by Flame-Plating.

Find out how Flame-Plating can help to improve your own product. Request a copy of the free booklet, "Flame-Plating," F8065. Address "Flame-Plating, Department SA-7."

FLP

Service Mark

The Flame-Plating gun consists mainly of a barrel and a mechanism for loading precise amounts of powder and gases into a firing chamber. The powder remains suspended in the explosive gases until a spark ignites the mixture, producing heat and pressure waves of tremendous force. The molten particles are hurled with supersonic velocity against the workpiece where they fuse and build up until the desired thickness is obtained.



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With this new attachment, Veeder-Root Rev-Counters can be installed on any engine having a tachometer take-off in a position which is readily accessible for easy reading. Take-off can be furnished to suit average engine-speed.

So now you can make it easier than ever for your customers to see that your product is performing up to its guarantee . . . to see when routine maintenance is coming due, and whether servicing is needed.

You can count on Veeder-Root to figure out how to engineer these adaptable Rev-Counters into *your* products . . . not only engines, but generators, compressors, heaters, refrigerators, and what have you? Write:

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P-34

From a new kind of plant comes a new breed of bearings—mated to the new needs of a mushrooming automobile industry

Introducing TIMKEN® and the Moto-Mated Way

A DESIGN revolution has created a new breed of cars that impose new demands on component parts.

To meet the big change in cars the Timken Company has introduced a whole new concept in bearing design, manufacture and supply, mated to the needs of a mushrooming auto industry. We call it the *Moto-Mated Way*. Launched in a revolutionary new plant, it re-cements our 57-year partnership with the automotive industry.

What *is* the Moto-Mated Way? 1) It's a forward-looking partnership with the automotive industry that anticipates your changing requirements. 2) It's providing you with a better product for less. 3) It's an almost unlimited source of supply. 4) It's putting advanced machines to work to provide even better jobs for the people in our plants.

Out of the Moto-Mated Way come new Timken® tapered roller bearing designs that are smaller, permitting more compact designs. Lighter, cutting unsprung weight, to give a better ride. Lower priced, off-setting spiralling costs. And packing maximum capacity in minimum space.

By adopting the new standardized Timken bearing sizes for front wheels, the auto industry has saved 11.3% or more over previous designs. And as use of the new sizes grows—in rear wheels, pinions and differentials—so will the savings.

Our engineers are eager to work drawing board to drawing board with you—as usual—to be sure you get all the extra advantages the Moto-Mated Way offers for design, production and purchasing. The Timken Roller Bearing Company, Canton 6, Ohio. Canadian plant: St. Thomas, Ontario. Cable address: "TIMROSCO".

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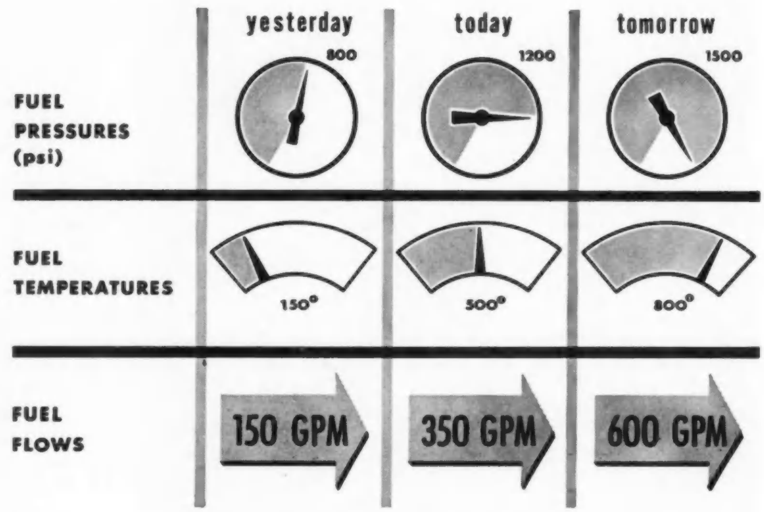
YOUR NO. 1 BEARING VALUE

PESCO REPORTS ON:

tomorrow's aircraft accessories

In well-equipped laboratories, in busy engineering offices, PESCO's "mind-power" is hard at work perfecting design concepts for tomorrow's aircraft accessories. These will be vital elements of the jet, rocket and nuclear-powered aircraft now being planned to meet the challenge of the Atomic Age.

This is a progress report from PESCO on what the future may hold for aircraft accessories.



Projected performance characteristics for tomorrow's aircraft fuel pumps.

ADVANCED DEVELOPMENTS

In development or preliminary design at PESCO are such unique products as pumps for propellants and special fuels—hydrogen peroxide, ethylene oxide, nitric acid, propyl nitrate and others; pumps for circulating liquid metal nuclear coolant; an electro-hydraulic nuclear control rod mechanism; electro-hydraulic servo transfer valves; and air and gas turbine drives.

Never content, PESCO engineers have set their sights on some eye-opening performance standards. For aircraft of the future, they foresee fuel pumps that will operate at fuel temperatures of 800° . . . pressures of 1,500 psi . . . and flows to 600 gpm. Propellant pumps will provide capacities to 5,000 gpm, nuclear coolant pumps will handle 15,000 gpm (see illustration).

DEVELOPMENT FACILITIES

Development of tomorrow's aircraft accessories will require extensive physical laboratory facilities . . . and PESCO has planned for this. At present, PESCO has: Hydraulics Laboratory, Fuel Laboratory, Electrical Laboratory and Materials Laboratory. By 1957, PESCO will have added a High Temperature Fuel Laboratory, a High Temperature Hydraulics Laboratory and a Propellant Laboratory. Longer-range plans call for an Advanced Propellant-Nuclear Coolant Laboratory. In addition, PESCO has available the central research facilities of its parent firm, Borg-Warner Corporation.

CURRENT DESIGN PROGRAMS

Active prototype development work is now well-advanced on main engine fuel pumps for almost all major aircraft engines including the most advanced turbojet, turboprop and gas turbine models. Equally vital are afterburner pumps for the turbojet engines which require them. Fuel booster pumps are being engineered for many planes and include such recent PESCO advances as line-mounted and plug-in types. Other projects include variable displacement hydraulic pumps and hydraulic motors.

CURRENT PRODUCTION

PESCO is more than a forward-looking development engineering organization—PESCO experience qualifies it as a top source for aircraft accessories. From PESCO production lines, the aircraft industry is now getting jet engine fuel pumps, fuel booster pumps, fuel flow controllers, hydraulic pumps, air and vacuum pumps, axial flow blowers, pilot's pressurization suit air conditioning packages, fuel valves, hydraulic valves and electric motors.

WHERE PESCO CAN HELP

With its engineering skills and technological resources, PESCO stands ready to help you with your new product design problems. If they involve the control or transmission of any pressurized materials, from air to liquid metals, our engineering staff will be glad to discuss them with you.

To develop *tomorrow's aircraft accessories* the alert, far-sighted technical group at PESCO is at the service of industry or government.

For *today's aircraft accessories*, PESCO is your most dependable source. For full information on PESCO services and products, contact your nearest PESCO sales engineer or write: PESCO, 24700 North Miles Road, Bedford, Ohio.

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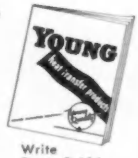

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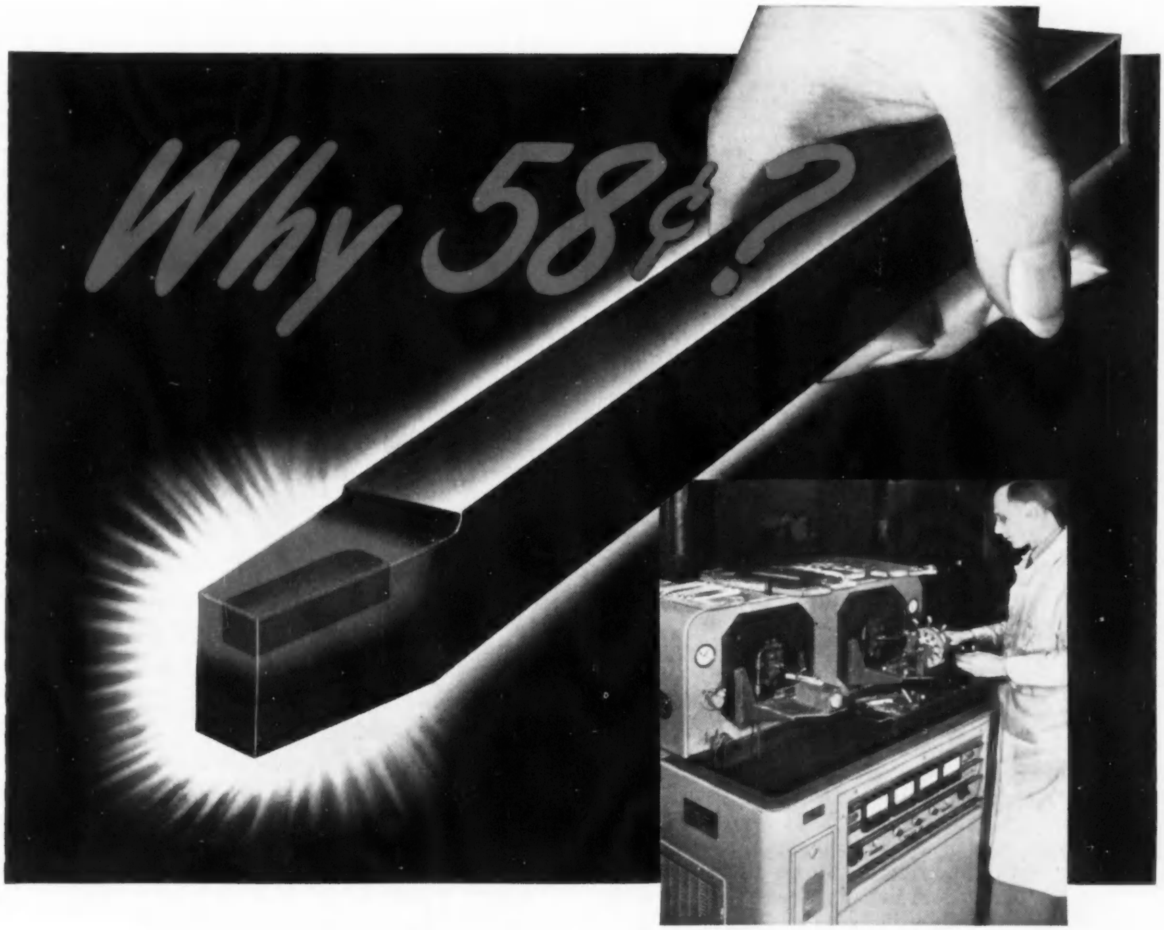
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Interested candidates should write to Tennessee Valley Authority, Examining Section, Knoxville, Tennessee.

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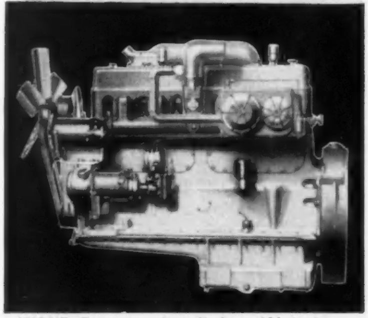

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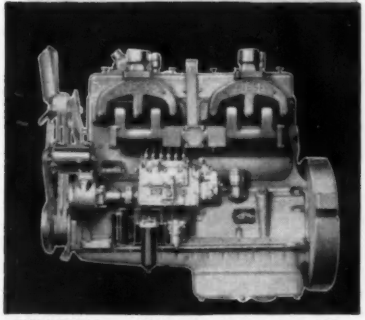

WAKDB Normal Diesel—six cylinders, 6¼-in. bore x 6½-in. stroke, 1197 cu. in. displacement, 258 hp at 1800 rpm.

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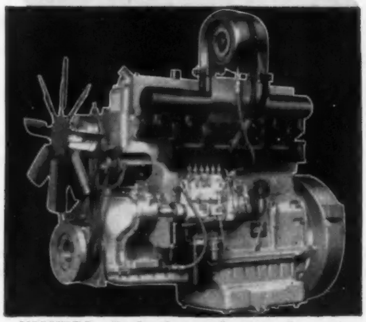

WAKDBS Turbocharged Diesel — six cylinders, 6¼-in. bore x 6½-in. stroke, 1197 cu. in. displacement, 352 hp at 1800 rpm.

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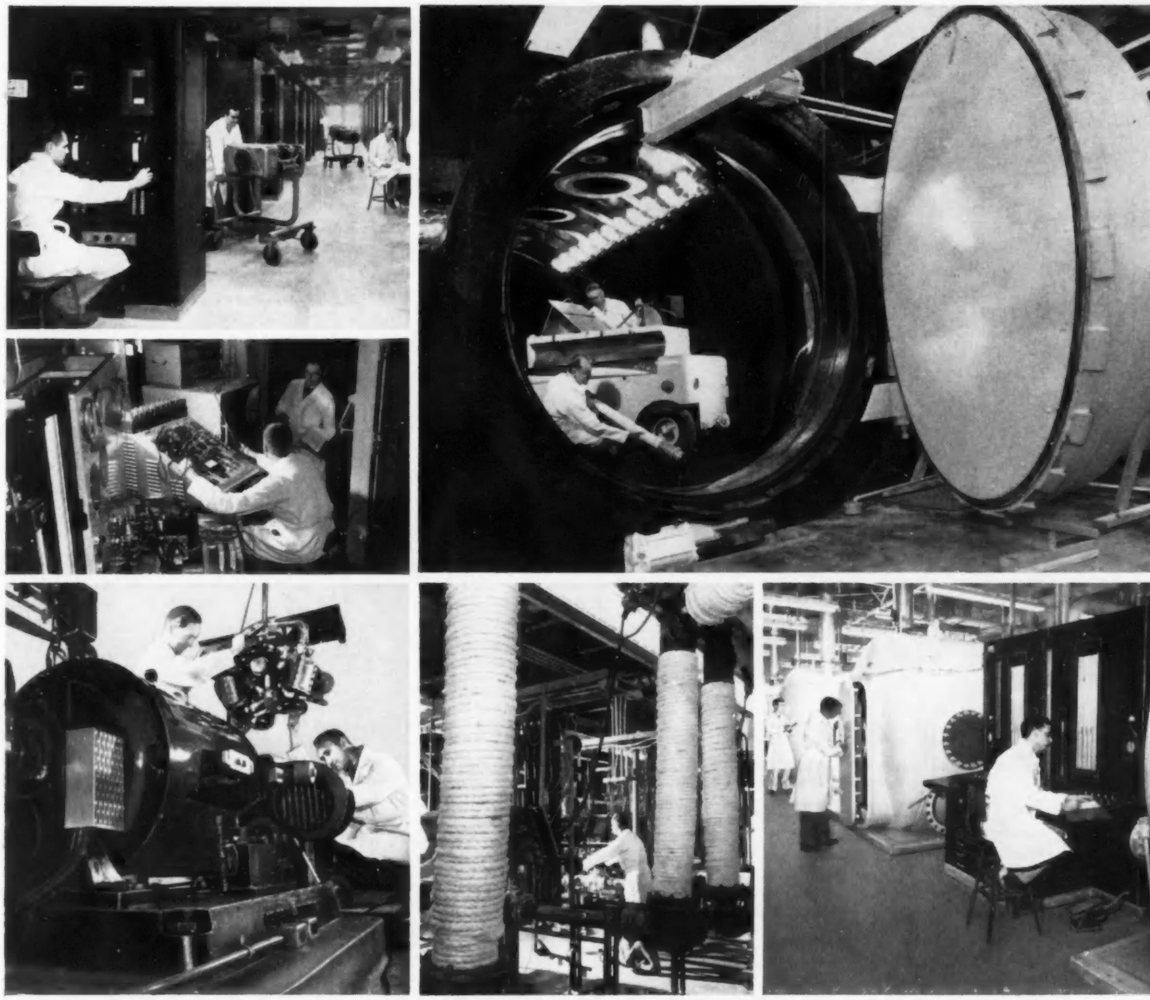

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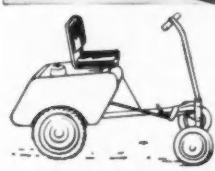

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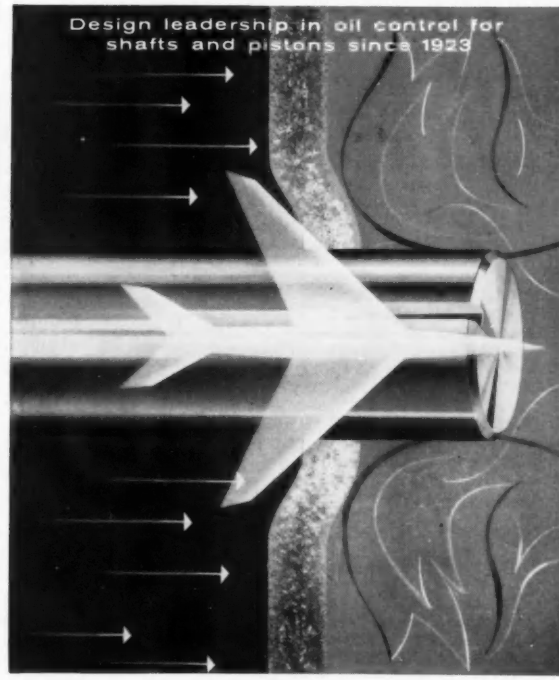

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